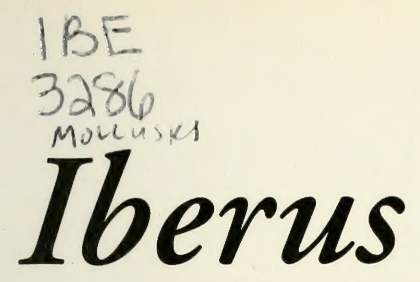
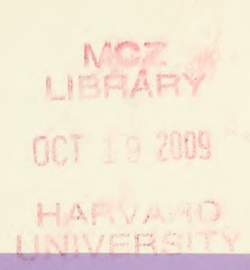


Iberus



Vol. 21 (2)

REVISTA DE LA SOCIEDAD ESPAÑOLA DE MALACOLOGÍA

Oviedo, diciembre 2003

Iberus

Revista de la

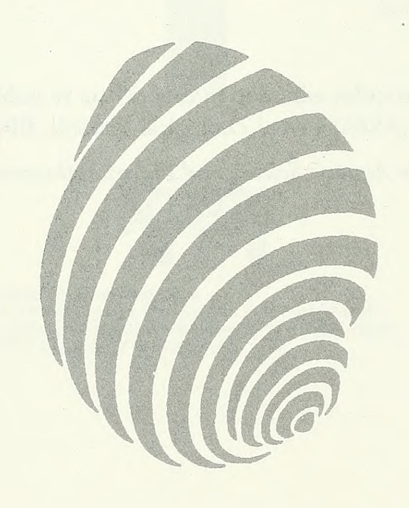
SOCIEDAD ESPAÑOLA DE MALACOLOGÍA

PORTADA DE *Iberus*

Iberus gualterianus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

Iberus

REVISTA DE LA SOCIEDAD ESPAÑOLA DE MALACOLOGÍA



Vol. 21 (2) **Oviedo, diciembre 2003**

Iberus

Revista de la

SOCIEDAD ESPAÑOLA DE MALACOLOGÍA

Iberus publica trabajos que traten sobre cualquier aspecto relacionado con la Malacología. Se admiten también notas breves. *Iberus* edita un volumen anual que se compone de dos o más números.

INSTRUCCIONES PARA LOS AUTORES

Los manuscritos deben remitirse a: D. Gonzalo Rodríguez, Apartado 156, 33600 Mieres del Camino, Asturias, España.

Los trabajos se entregarán por triplicado (original y dos copias). Se recomienda a los autores leer cuidadosamente las normas de publicación que se incluyen en cada número de la revista.

SUBCRIPCIONES

Iberus puede recibirse siendo socio de la Sociedad Española de Malacología, en cualquiera de sus formas, o mediante intercambio. Aquellos socios que deseen adquirir números atrasados deberán dirigirse al bibliotecario.

Los no socios deberán ponerse en contacto con BACKHUYS PUBLISHERS, P.O. Box 321, 2300 AH Leiden, The Netherlands. Tel.: +31-71-51 70 208, Fax: +31-71-51 71 856, Correo Electrónico: backhuys@euronet.nl

Los resumenes de los artículos editados en esta revista se publican en Aquatic Science and Fisheries Abstracts (ASFA) y en el Zoological Records, BIOSIS.

Contents list published in Aquatic Science and Fisheries Abstracts and Zoological Records, BIOSIS.

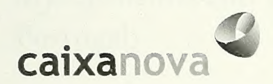
Dep. Leg. B-43072-81

ISSN 0212-3010

Diseño y maquetación: Gonzalo Rodríguez

Impresión: LOREDO, S. L. - Gijón

Entidades Colaboradoras



















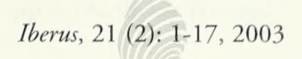






Este número contiene algunos trabajos presentados en el II Congreso Internacional de las Sociedades Malacológicas Europeas, celebrado en Vigo, del 9 al 13 de Septiembre de 2002, habiendo sido parcialmente subvencionado por las ayudas a dicho Congreso

© Sociedad Española de Malacología —————— Iberus, 21 (2): 1-17, 2003



Characterization and multivariate analysis of *Patella intermedia*, *Patella ulyssiponensis* and *Patella vulgata* from Póvoa de Varzim (Northwest Portugal)

Caracterización y análisis multivariante de *Patella intermedia*, *Patella ulyssiponensis* and *Patella vulgata* de Póvoa de Varzim (noroeste de Portugal)

João Paulo CABRAL*

Recibido el 9-IX-2002. Aceptado el 13-I-2003

ABSTRACT

Samples of *Patella intermedia*, *Patella ulyssiponensis* and *Patella vulgata* were collected from the lowest to the highest level of A Ver-o-Mar and Aguçadoura beaches (Póvoa de Varzim, Portugal). Identification of the specimens was based on the morphology of the radula pluricuspid teeth and of the shell. Regressions of shell width or shell apexpos *vs.* shell length yielded slopes not statistically different, but slopes of log shell height *vs.* shell length regression lines were significantly different, indicating that these limpets have different shell growing patterns. However, canonical discriminant analyses using only variables describing shell form yielded poor discrimination between species. Analysis using only variables describing radula relative size improved discrimination, was very satisfactory for *P. ulyssiponensis* specimens, but resulted in a low identification of *P. intermedia*. The best results were achieved using both shell form and radula relative size variables, and the most discriminating variable was radula length/shell height ratio, instead of radula length/shell length as reported in the literature. However, whereas correct identification of *P. ulyssiponensis* specimens was very good (higher than 95 %), for *P. intermedia* and *P. vulgata*, this value ranged from 70 – 80 %. In light of data reported in the literature, morphometric characteristics such as those utilized in this work are probably useful for characterization of *P. ulyssiponensis* as a species, but are of limited value for *P. intermedia* and *P. vulgata*. Qualitative characters are thus still indispensable for the discrimination between these two *Patella* species. Very good qualitative discriminators were, for *P. intermedia*, the tall and broad cusp 2 and the dark marginal rays in the shell interior surface, and for *P. vulgata*, the pointed protuberance on cusp 3, and the silvery head scar.

RESUMEN

Muestras de *Patella intermedia*, *Patella ulyssiponensis* y *Patella vulgata* fueron colectadas en una franja abarcando desde el nivel mas bajo al mas alto de las playas de A Ver-o-Mar y Aguçadoura (Póvoa de Varzim, Portugal). La identificación de los especimenes se basó en la morfología de la concha y de los dientes pluricúspides de la rádula. Las pendientes de las regresiones entre la anchura o el apexpos (distancia entre la proyección del ápice y la parte posterior de la concha) de la concha y la longitud de la concha no difirieron estadís-

* University of Oporto, Center of Marine and Environmental Research (CIIMAR) and Faculty of Sciences, Rua do Campo Alegre, 1191, 4150-181 Porto, Portugal. jspcabral@hotmail.com

ticamente, mientras que las pendientes de las regresiones entre el logaritmo de la altura y la longitud de la concha fueron significativamente diferentes, indicando que estas lapas presentan patrones de crecimiento distintos. Sin embargo, el análisis canónico discriminatorio utilizando solo las variables que describen la forma de la concha tuvo un bajo poder de discriminación entre especies. Al utilizar solo las variables que describen el tamaño relativo de la rádula se mejoró el poder discriminatorio del análisis, y aunque permitió una identificación satisfactoria de *P. ulyssiponensis*, pero resultó tener bajo poder para la identificación de *P. intermedia*. Los mejores resultados se obtuvieron utilizando variables relacionadas tanto con la forma de la concha como con el tamaño relativo de la rádula, y la variable con mayor poder discriminatorio fue la razón longitud de la rádula/altura de la concha, en lugar de longitud de la rádula/longitud de la concha, como se ha reportado en la bibliografía. Mientras que la correcta identificación de especimenes de *P. ulyssiponensis* fue muy alta (mayor que 95 %), para *P. intermedia* y *P. vulgata*, este valor varió entre 70 – 80 %. A la luz de los datos publicados en la bibliografía, características morfométricas tales como las utilizadas en el presente trabajo, pueden ser de gran utilidad para la caracterización específica de *P. ulyssiponensis*, pero tienen un valor limitado para la caracterización de *P. intermedia* y *P. vulgata*. Las características cualitativas, por tanto, siguen siendo indispensables para la discriminación ente estas dos especies de *Patella*. Para *P. intermedia*, la segunda cúspide alta y ancha, así como los radios marginales oscuros en la superficie interna de la concha, constituyeron muy buenos discriminadores cualitativos, mientras que para *P. vulgata*, lo fueron la protuberancia puntiaguda en la tercera cúspide, junto con la cicatriz de la cabeza de color plateada.

KEY WORDS: *Patella*, radula, canonical discriminant analysis, morphometry.
PALABRAS CLAVE: *Patella*, rádula, annalisis canónico discriminante, morfometría.

INTRODUCTION

The characterization and delimitation of *Patella intermedia* Murray in Knapp 1857, *Patella ulyssiponensis* Gmelin 1791, and *Patella vulgata* Linné 1758, has been a source of debate and controversy since they were proposed as species (Fisher-Piette, 1935; Rampal, 1965; Ibañez, 1982). This was due to the high shell variability commonly exhibited by these species. In regions of low variability, *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* shells are usually distinct from each other. In regions of high variability, however, some shells display intermediate characteristics, and reliable identification of these species based on shell morphology alone is difficult (Fisher-Piette, 1934, 1948, 1966; Evans, 1947, 1958; Fisher-Piette and Gaillard, 1959). Shell variability of *P. vulgata* and *P. intermedia* is highest in the Basque coast of France and Spain, and in the south limit of their distribution, the Algarve (Portugal) for *P. vulgata*, and northern Africa for *P. intermedia*. *P. ulyssiponensis* is the species with the least variable shell (Fischer-Piette and Gaillard, 1959; Fisher-Piette, 1966).

The difficulties in the identification of *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* specimens based on shell morphology alone led to the search for new characters. Dautzenberg, in the end of the 18th century, pointed out the importance of radula length and pigmentation of mantle tentacle to discriminate several *Patella* species, being therefore the first malacologist to propose alternative characteristics to shell morphology (Fischer-Piette and Gaillard 1959; Rampal, 1965). The work of Fisher-Piette (1934, 1935) showed, for the first time, that the morphology of the radula pluricuspid teeth could be used to characterize several *Patella* species, since they usually display low intraspecific variability, and

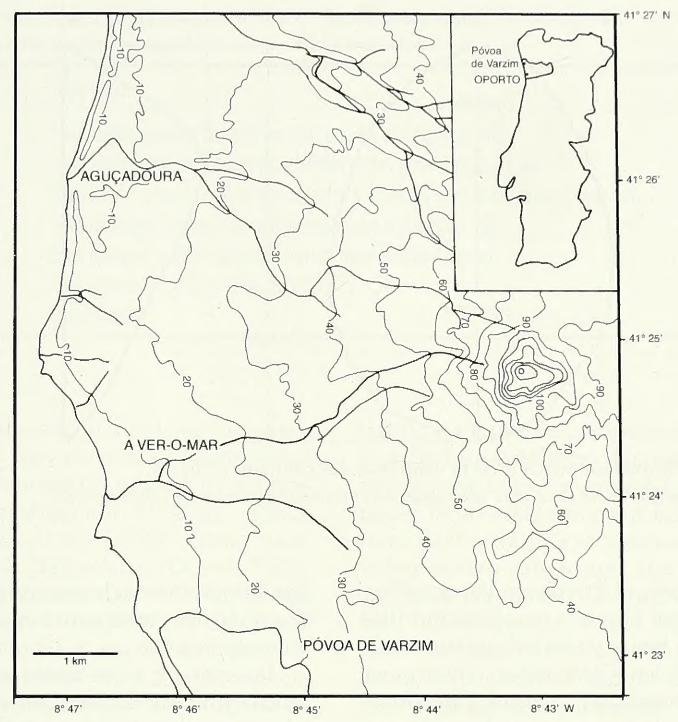


Figure 1. Location of sampling sites (A Ver-o-Mar and Aguçadoura beaches) near Póvoa de Varzim Inset: Localization of the town of Póvoa de Varzim and Oporto district in Portugal.
Figura 1. Ubicación de la zona de muestreo (playas de A Ver-o-Mar y Aguçadoura) en las cercanías de Póvoa de Varzim. Recuadro: Ubicación del pueblo de Póvoa de Varzim y el distrito de Oporto en Portugal.

marked interspecific differences. Fisher-Piette initial observations were confirmed by ESLICK (1940) and EVANS (1947). In a latter paper, FISHER-PIETTE AND GAILLARD (1959) showed that radula unicuspid teeth could also be used to characterize several *Patella* species.

Other characteristics have been proposed for specific discrimination in the genus *Patella*: the foot colour, the breeding seasons, and the ratio of the radula length / cubic root of the shell volume (FISHER-PIETTE, 1935, 1941, 1948; EVANS, 1947, 1953, 1958; FISHER-PIETTE AND GAILLARD, 1959; RAMPAL, 1965; POWELL, 1973).

In this study, samples of *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim (northwest Portugal) were examined and compared with respect to several morphological and morphometric characters describing the radula, shell, and soft parts. In particular the following questions were raised:

- How variable are these species in Póvoa de Varzim?
- Is shell form similar in these limpets?
- Are radula and shell characteristics equally important for the separation of these species?
- Can these species be discriminated by morphometric characters alone, rather than by morphological characteristics?

MATERIAL AND METHODS

Collections were made at A Ver-o-Mar and Aguçadoura beaches, two very similar and exposed shores situated

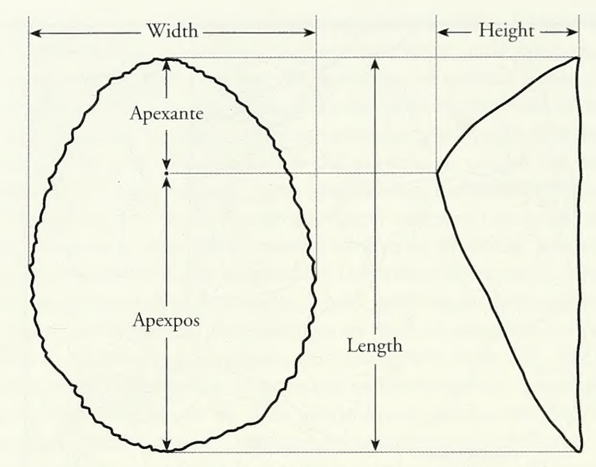


Figure 2. Shell measurements used in canonical discriminant analysis.
Figura 2. Mediciones de la concha utilizadas en el análisis canónico discriminatorio.

near the town of Póvoa de Varzim (Fig. 1). The upper shore is composed of dispersed and heavily eroded granite boulders. Barnacles (*Chthamalus*) cover most of the surfaces and *P. vulgata* is the dominant limpet. Some mussels and gastropods live in the crevices. The middle shore is composed of horizontal granite platforms, very eroded, with small sandy beaches in between. *P. intermedia* and *P. vulgata* are common in middle shore. *P. ulyssiponensis* is restricted to lower shore levels, where *P. intermedia* and *P. vulgata* also occur. Most of the *P. ulyssiponensis* shells are covered with abundant *Gelidium pulchelum* (Turner) Kützing. Common macroalgae in the middle and lower shore include *Bifurcaria bifurcata* R. Ross, *Chondrus crispus* Stackhouse, *Codium tomentosum* (Hudson) Stackhouse, coralline rhodophytes, *Cystoseira* sp., *Enteromorpha* spp., *Gigartina pistillata* (Gmelin) Stackhouse, *Gracilaria verrucosa* (Hudson) Papenfuss, *Lythophyllum* spp., *Mastocarpus stellatus* (Stackhouse in Withering) Guiry and *Sargassum muticum* (Yendo) Feusholt. Sampling took place in January and November 2000, at low tide.

Specimens were collected from the lowest to the highest level of the shores. Squared areas with ca. 30 x 30 cm were marked at random in each level, and all the animals in each area removed from the rock. The total number of collected animals was 608.

Specimens were analysed for foot, radula and shell characteristics. In the laboratory, the animals were observed for the foot colour, and then immersed for a few minutes in boiling water to separate the shell from the soft part. The radula was removed from the visceral mass by dissection, immersed in household bleach to remove mucilaginous substances, washed in distilled water, and measured to the nearest 1mm using a ruler. After air-drying, pluricuspid teeth were first observed using a binocular microscope, with 80 x final magnification. Structural details of the teeth were observed by scanning electron microscopy, in selected specimens. The samples were gold coated (in a JEOL JFC1100 model; film thickness less then 20 nm), and observed in a JEOL JSM-35C model scanning electron microscope, working at 15 keV, with 39 mm working distance.

The external and internal shell surfaces were examined and their characteristics were recorded. Shell length, width, height, apexante and apexpos (Fig. 2 and Table I for the definition of these measures) were then determined to the nearest 0.01mm using a digital calliper (Mitutoyo, model CD-15DC).

Table I. Characters used in the canonical discriminant analysis.
Tabla I. Caracteres usados en el análisis canónico discriminante.

Acronym	Description
SL	Shell length: greatest distance between anterior and posterior ends
SW	Shell width: greatest distance perpendicular to the anterior-posterior axis
SH	Shell height: greatest vertical distance from apex of the shell to the plane of aperture
SAA	Shell apexante: greatest distance between apex and anterior end
SAP	Shell apexpos: greatest distance between apex and posterior end
SV	Shell volume = $(\pi/3) \times (SW/2) \times (SL/2) \times SH$
RL	Radula length

Morphometric analysis of the shell and radula was carried out using the variables commonly utilized in studies of patellogastropoda (IBAÑEZ, 1982; IBAÑEZ AND FELIU, 1983; FELIU AND IBAÑEZ, 1984; HERNÁNDEZ-DORTA, 1992; SIMISON AND LINDBERG, 1999). The mean and coefficient of variation of the mean was calculated for each variable and species. Linear regression analysis using the least squares method was applied to pairs of shell or radula variables. These calculations were carried out using Microsoft® Excel 2000 program. Comparison of the slopes was carried out by analysis of covariance using the statistical procedure described by ZAR (1984).

Canonical discriminant analysis on shell and radular morphometric variables was used to reveal differences among the populations, and to identify the variables that were responsible for the majority of separation between species. Discriminant analyses were carried out in several steps. Firstly, using *a posteriori* probabilities and no selection of variables, four discriminant analyses were carried out, two using only shell characters, one with only radula characters, and one using simultaneously shell and radula characters. Secondly, using *a posteriori* probabilities, and simultaneously shell and radula characters, discriminant analysis was carried out with stepwise selection of variables. Significance level "to enter" and "to stay" the variables was set at 0.15. Thirdly, cross-validation analysis (using *a priori* probabilities) was undertaken to assess the reliability of previous findings (using *a posteriori* probabilities). For each species, specimens were re-ordered randomly using Excel 2000 program RAND function. Each group (species) was then divided in two subgroups. For *P. intermedia*, these contained 152 specimens each, for *P. ulyssiponensis*, 33 and 32, each, and for *P. vulgata*, 119 and 120. The first group (the analysis sample containing the training or calibration data) was used to derive the discriminant functions, coefficients, and loadings. The second group (the houldout sample containing the test data) was used to test the discriminant functions, by classifying each specimen into one of the *Patella* species. This process was repeated ten times. At each run, a percent correct identification to species was evaluated. The means of these values were compared with those obtained by using *a posteriori* probabilities. Discriminant analyses were performed using the NCSS (NCSS Statistical Software, Utah, USA) and XLSTAT 5.1 (Addinsoft, Paris, France) software packages.

RESULTS

I. Delimitation of species

Based on radular and shell morphology, the collected specimens were divided into three groups. Within each group, radula pluricuspid teeth displayed low variability, and shells exhibited limited morphological variation.

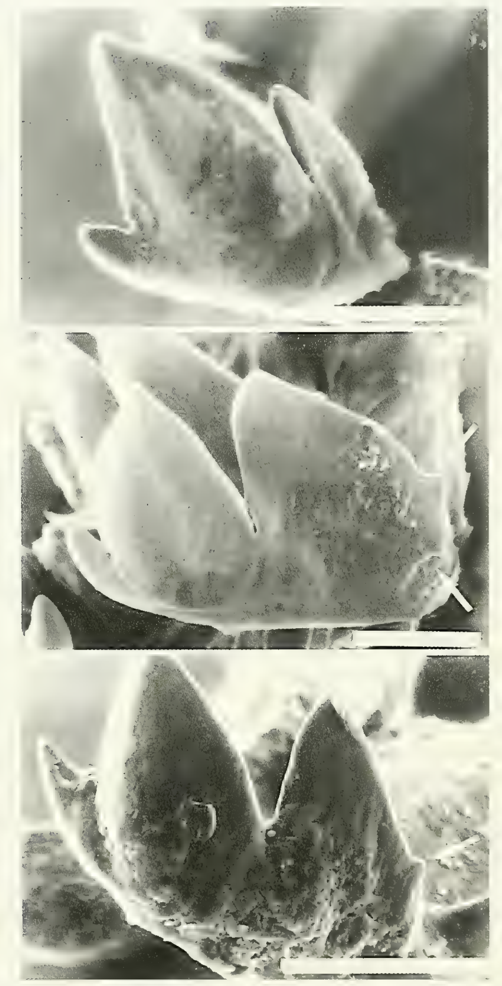


Figure 3. Morphology of pluricuspid teeth of the radula. Numbering of the cusps begins from left to the right (corresponding to the outer and inner sides of the radula). Top: *Patella intermedia*. Cusp 2 is taller and broader than cusps 1 and 3. Middle: *Patella ulyssiponensis*. Cusp 2 is directed to cusp 3. Cusp 3 is wither than cusp 2. Cusp 3 has a protuberance on its outer side. Bottom: *Patella vulgata*. Cusps 2 and 3 subequal. Cusp 3 has a pointed projection on its outer side border. Scale bars 100 µm.
Figura 3. Morfología de los dientes pluricúspides de la rádula. La numeración de las cúspides comienza desde la izquierda hacia la derecha (correspondiendo a los lados externos e internos de la rádula). Superior: Patella intermedia. *La segunda cúspide es más alta y ancha que la primera y tercera. Medio:* Patella ulyssiponensis. *La segunda cúspide está dirigida hacia la tercera. Esta última es más ancha que la segunda. La tercera cúspide tiene una protuberancia sobre el lado externo. Inferior:* Patella vulgata. *Las segunda y tercera cúspides son subiguales. La tercera tiene una proyección puntiaguda en el borde externo. Escalas 100 µm.*

The three groups displayed the following features:

Group I. Three unequal pluricuspid teeth (Figure 3, top). Cusp 2 (centre) much taller and broader than cusps 1 (left) and 3 (right). Margin of the shell rimose, with pointed extensions connected to the rays (Figure 4). External surface with few and prominent ribs. Interior with alternating dark and light



Figure 4. *Patella intermedia* shells from A Ver-o-Mar and Aguçadoura beaches.
Figura 4. Conchas de Patella intermedia *provenientes de las playas de A Ver-o-Mar y Aguçadoura.*

rays, in the lower part. Head scar yellow-orange, but creamy in a few specimens.

Group II. Three unequal pluricuspid teeth (Figure 3, middle). Cusp 1 (left) very small. Cusp 2 (centre) bent to cusp 3 (right). Base of cusp 3 wider than cusp 2. Cusp 3 with a protuberance on its outer side – a vestigial fourth cusp. Margin of the shell finely crenulate (Figure 5). External surface crowded by numerous, closely spaced, well-marked ribs, of unequal size. Interior homogeneous, porcelanous white. Head scar white, creamy or pale orange.

Group III. Three unequal pluricuspid teeth (Figure 3, bottom). Cusp 1 (left) small. Cusps 2 (centre) and 3 (right) subequal. Cusp 3 with a pointed protu-

berance on its outer side border. Margin of the shell entire or slightly indented (Figure 6). External surface smooth at the apex, with flat and spaced ribs below. Interior with transparent nacre, often with a green or blue iridescence. Silvery head scar.

Based on shell and radula morphological characters reported in the literature for *Patella* spp. (Fisher-Piette, 1934, 1935; Fisher-Piette and Gaillard, 1959; Evans, 1947, 1953; Rolán, 1993; Rolán and Otero-Schmitt, 1996), groups I, II and III were unequivocally identified as belonging to *P. intermedia, P. ulyssiponensis* and *P. vulgata,* respectively.

Radula pluricuspid teeth of *P. intermedia* from Póvoa de Varzim is similar to *P. intermedia* type B of Evans (1953), and to those reported by Fisher-Piette (1934, figure 2), Fisher-Piette (1935, figure 9, figure 17-2) and Fisher-Piette and Gaillard (1959, figure 11 A and B).

Radula pluricuspid teeth of *P. ulyssiponensis* from Póvoa de Varzim is similar to *P. ulyssiponensis* type A of Evans (1953), and to those reported by Fisher-Piette (1934, figure 2), Fisher-Piette (1935 – figure 10, figure 17-9) and Fisher-Piette and Gaillard (1959 – figure 14 B).

Radula pluricuspid teeth of *P. vulgata* from Póvoa de Varzim is similar to *P. vulgata* types A and B of Evans (1953), and to those reported by Fisher-Piette (1934, figure 2), Fisher-Piette (1935, figure 8, figure 17-1) and Fisher-Piette and Gaillard (1959, figure 9A).

P. intermedia, P. ulyssiponensis and *P. vulgata* shells from Póvoa de Varzim are morphologically similar to those found in Galiza (northwest Spain) (Rolán, 1993; Rolán and Otero-Schmitt, 1996) and at Cardigan Bay (Wales, Great Britain; Evans, 1947).

The foot showed no constant colouration within each group, and therefore was not used in the identification. *P. intermedia* foot was dark, from grey or yellow to black. *P. ulyssiponensis* foot was light, yellow or, most often, orange. The colour of *P. vulgata* foot was very variable, from light yellow to black.

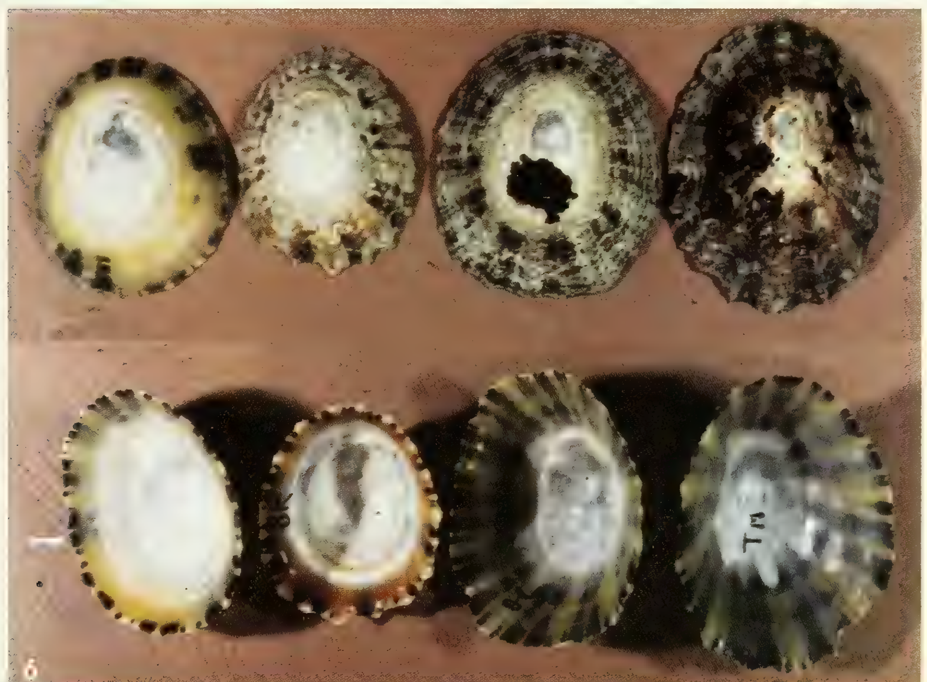
II. Morphometric delineation of species

For all three *Patella* species, SW and SA was a linear function of SL (Table II). However, SH was a curvilinear function of SL, indicating that as these limpets increase in size, the relative height of the shell increases by a power function. Similar relationship between SH and SL has been reported for several *Notoacmea* (Lindberg, 1982) and *Patella* species (Davies, 1969; Muñoz and Acuña, 1994). Correlation between SH and SL increased after log transformation of SH, indicating that an exponential fit was a better approach than a linear function.

Regressions of SW or SAA *vs.* SL for *P. intermedia, P. ulyssiponensis* and *P. vulgata* specimens yielded slopes not statistically different (Table II). However, slopes of log SH *vs.* SL regression lines were significantly different (Table II), indicating that the relative increase in height as the shell grows was not uniform in these *Patella* species. Slopes increased in the order *P. ulyssiponensis, P. vulgata,* and *P. intermedia.*

For all three *Patella* species, RL was a linear function of SL and of $\sqrt[3]{(SV)}$ (Table II). Similar relationship between RL and SL has been reported for several *Patella* species (Brian and Owen, 1952; Davies, 1969; Sella, 1976). Slopes of the regression lines were significantly different, and increased in the order *P. ulyssiponensis, P. intermedia,* and *P. vulgata* (Table II).

In *P. intermedia, P. ulyssiponensis* and *P. vulgata,* radula relative size displayed higher variability than shell form. Whilst the coefficient of determination for the regressions describing shell form (SW *vs.* SL, log SH *vs.* SL, and SAP *vs.* SL) ranged between 0.597 and 0.952, those describing radula relative size (RL *vs.* SL, and RL *vs.* $\sqrt[3]{(SV)}$) varied between 0.472 and 0.767 (Table II). Whilst the coefficient of variation of the means describing shell form (SW/SL, SH/SL, SAA/SAP, and SAP/SL) varied between 5.4 and 22 %, those describing radula relative size (RL/SL, RL/SH,



Figures 5, 6. *Patella* shells from A Ver-o-Mar and Aguçadoura beaches. 5: *P. ulyssiponensis*; 6: *P. vulgata*.
Figuras 5, 6. Conchas de Patella *provenientes de las playas de A Ver-o-Mar y Aguçadoura. 5:* P. ulyssiponensis*; 6:* P. vulgata.

Table II. Slopes of regression lines for morphometric characterization of the species, and their statistical comparison.
Tabla II. Pendientes de las rectas de regresión de la caracterización morfomética de las especies, y su comparación estadística.

Regression	*P. intermedia*		*P. ulyssiponensis*		*P. vulgata*		Comparison of slopes (DF=2, 604)
	Slope	r^2	Slope	r^2	Slope	r^2	F
Shell							
SW *vs.* SL	0.859	0.952	0.791	0.918	0.821	0.929	3.719^{NS}
Log_{10} SH *vs.* SL	0.0241	0.744	0.0149	0.597	0.0182	0.754	23.1***
SAP *vs.* SL	0.608	0.859	0.570	0.834	0.627	0.939	2.311^{NS}
Radula							
RL *vs.* SL	1.29	0.472	0.712	0.625	1.40	0.501	8.557***
RL *vs.* $\sqrt[3]{(SV)}$	2.89	0.485	1.89	0.767	3.15	0.556	5.690***

^{NS} Not significant at 0.02 level
*** Significant at 0.005 level

RL/SAA, and RL/$\sqrt[3]{(SV)}$) varied 9.6 and 28 % (Table III). Concerning the radula relative size, *P. ulyssiponensis* was the least variable species (Table III).

III. Discrimination between species

In order to determine which variables provided the best discrimination between species, several canonical discriminant analyses were carried out using different techniques and different sets of radula and/or shell characteristics. Results are displayed in Tables IV - VII.

Analysis I and II, using only variables describing shell form, resulted in a very poor discrimination between species, with only 65 % of the specimens *a posteriori* correctly identified to species (Table IV). The first canonical variable accounted for 91 % of the variation between species, and the variable with the highest loading was SH/SL (data not shown). Analysis III, using only variables describing radula relative size, was better than analyses I and II, and was very satisfactory for *P. ulyssiponensis*, but resulted in a low *a posteriori* correct identification of *P. intermedia* specimens (Table IV). The first canonical variable accounted for 76 % of the variation between species, and the variables with the highest loadings were RL/SH followed by RL/$\sqrt[3]{(SV)}$ (data not shown) The simultaneous use of variables describing shell form and variables describing radula relative size (Analysis IV) was better than the use of one of these groups of variables alone (Table IV). However, the improvement of Analysis IV over Analysis III was limited. *A posteriori* correct identification of *P. ulyssiponensis* specimens was unchanged (and very good), but identification of *P. intermedia* and *P. vulgata* specimens was lower than 80 % (Table IV). The first canonical variable accounted for the great majority of the variation between species, and the second canonical discriminant variable accounted for only 23.7 % of the variance (Table VI). The variables that provided the highest contrast between the three *Patella* species were RL/SH followed by RL/$\sqrt[3]{(SV)}$, and then RL/SL (Table VII). Individuals were plotted along the two canonical variables (Figure 7). There was a considerable overlap between *P. intermedia* and *P. vulgata* specimens, but a reasonable discrimination of *P. ulyssiponensis* individuals. Stepwise selection of variables describing shell form and radula rela-

Table III. Morphometric characterization of the species.
Tabla III. Caracterización morfométrica de las especies.

Variable	*P. intermedia* (n= 304)		*P. ulyssiponensis* (n= 65)		*P. vulgata* (n= 239)	
	Mean	CV (%)	Mean	CV(%)	Mean	CV(%)
Shell						
SW/SL	0.822	5.8	0.764	6.3	0.793	5.6
SH/SL	0.279	19	0.318	18	0.346	17
SAA/SAP	0.479	22	0.509	16	0.523	15
SAP/SL	0.682	7.0	0.665	10	0.658	5.4
Radula						
RL/SL	1.68	19	0.934	12.4	1.55	20
RL/SH	6.24	26	2.99	14	4.54	20
RL/SAA	5.44	28	2.84	22	4.59	25
RL/$^3\sqrt{(SV)}$	4.32	19	2.35	9.6	3.73	19

Table IV. Number and percent correct identification of the specimens, based on canonical analyses using different sets of shell and/or radula characters.
Tabla IV. Número y porcentaje de identificación correcta de los especímenes, basado en el análisis canónico usando diferentes conjuntos de caracteres de concha y/o rádula.

Analysis	Variables	*P. intermedia* (n= 304)		*P. ulyssiponensis* (n= 65)		*P. vulgata* (n= 239)		Overall Mean
		N	%	N	%	N	%	%
I	SW/SL SH/SL SAA/SAP	223	73.4	34	52.3	138	57.7	65.0
II	SW/SL SH/SL SAP/SL	222	73.0	34	52.3	139	58.2	65.0
III	RL/SL RL/SH RL/SAA RL/$^3\sqrt{(SV)}$	202	66.4	64	98.5	194	81.2	75.7
IV	SH/SL SAA/SAP RL/SL RL/SH RL/SAA RL/$^3\sqrt{(SV)}$	220	72.4	64	98.5	187	78.2	77.5
V	SH/SL RL/SL RL/SH RL/SAA RL/$^3\sqrt{(SV)}$	222	73.0	64	98.5	187	78.2	77.8

Table V. Percent correct identification of the specimens based on canonical discriminant analysis using shell and radula characters (SH/SL, SAA/SAP, RL/SL, RL/SH, RL/SAA, and RL/$\sqrt[3]{(SV)}$). Cross-validation analysis using half number of specimens for calibration and half for test.
Tabla V. Porcentaje de identificación correcta de los especímenes, basada en el análisis canónico discriminante usando caracteres de la rádula y concha (SH/SL, SAA/SAP, RL/SL, RL/SH, RL/SAA, and RL/$\sqrt[3]{(SV)}$). Análisis de validación cruzada usando la mitad de los especímenes para la calibración y la otra mitad para el test.

	P. intermedia	*P. ulyssiponensis*	*P. vulgata*	Overall Mean
Mean	70.9	96.6	77.1	76.0
CV (%)	5.6	3.6	5.2	3.3

Table VI. Eigenvalues and Wilks' λ of canonical discriminant analysis using shell and radula characters (SH/SL, SAA/SAP, RL/SL, RL/SH, RL/SAA, RL/$\sqrt[3]{(SV)}$). Significance of Wilks' λ was evaluated by Fisher's F values.
Tabla VI. Autovalores y λ de Wilks del análisis canónico discriminante usando caracteres de la concha y rádula (SH/SL, SAA/SAP, RL/SL, RL/SH, RL/SAA, RL/$\sqrt[3]{(SV)}$). La significatividad de la λ de Wilks se evaluó con los valores de la F de Fisher.

	Eigenvalue	% of Variance		Canonical correlation	Wilks' **λ**
		Individual	Cumulative		
First canonical variate	0.820	76.3	76.3	0.671	0.438***
Second canonical variate	0.255	23.7	100	0.450	0.797***

*** Significant at 0.01 level

Table VII. Total canonical structure for discriminant analysis of *Patella* species. Variables with the highest loadings are in bold.
Tabla VII. Estructura canónica total para el análisis discriminante de las especies de Patella. *Las variables con mayores cargas están en negrita.*

Variable	First canonical variable	Second canonical variable
SH/SL	-0.556	0.711
SAA/SAP	-0.306	0.327
RL/SL	0.777	**0.607**
RL/SH	**0.969**	-0.053
RL/SA	0.758	0.274
RL/$\sqrt[3]{(SV)}$	**0.901**	0.388

tive size (Analysis V, Table IV) resulted in the removal of SAA/SAP, but the *a posteriori* correct identification to species was only very slightly improved. The removal of SAA/SAP was expected since it was the variable that provided the lowest contrast between the three limpet species (Table VII).

Analysis I – V were carried out using *a posteriori* probabilities. In this technique, the same data set that is used to derive the discriminant functions is also

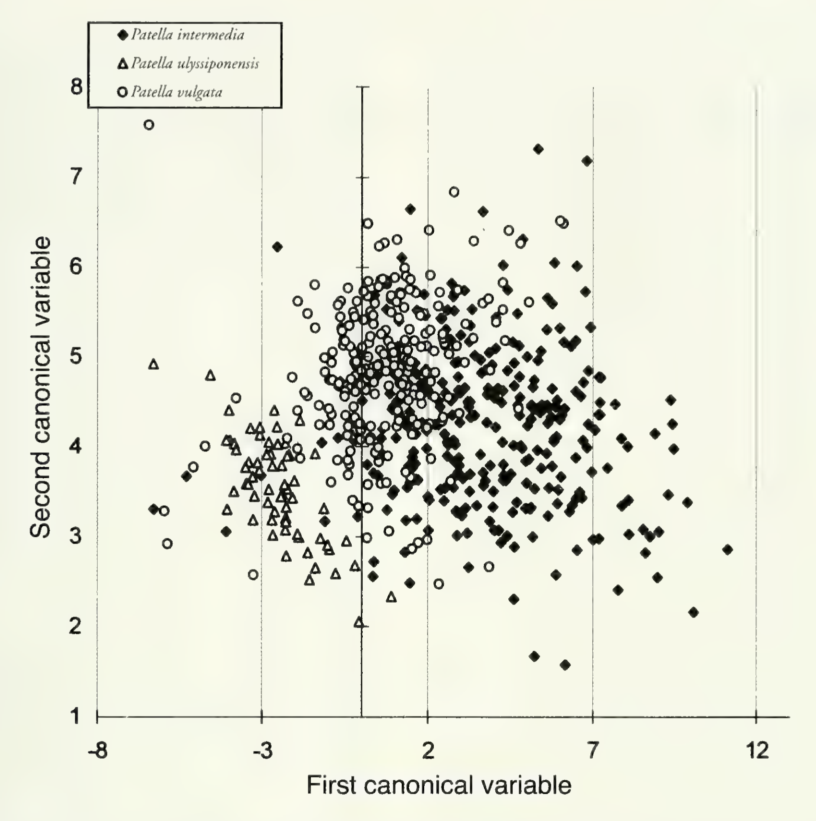


Figure 7. Scatter plot of the first and second canonical variables in the discriminant analysis using shell and radula measurements (Analysis IV). The variables most closely associated with the discrimination between species were RL/SH and RL/$^3\sqrt{}$(SV).

Fig. 7. Gráfica de la primera y segunda variables canónicas del análisis discriminatorio realizado utilizando mediciones de la concha y la rádula (Análisis IV). Las variables que más fuertemente influencian la discriminación entre especies fueron RL/SH y RL/$^3\sqrt{}$(SV).

used to test the accuracy of the predictions using these functions. In order to test the reliability of these results, an *a priori* technique was used with a cross-validation of the data. Mean percentages of correct identification of the specimens using this technique (Table V) were very similar to those obtained with *a posteriori* probabilities (Table IV, Analysis IV), indicating high within-group (species) homogeneity of specimens. Only *P. ulyssiponensis* specimens were very well correctly identified. Percent correct identification of *P. intermedia* and *P. vulgata* specimens were again lower than 80 % (Table V).

DISCUSSION

I. Shell form

Results presented in this work showed that *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim region have different shell growing patterns. Although SW or SAA *vs.* SL regressions showed slopes not significantly different in these *Patella* species, log SH *vs.* SL regressions displayed significantly different slopes. The fastest growing species in height was *P. intermedia*, and the slowest *P. ulyssiponensis*, *P. vulgata* displaying intermediate behaviour.

II. Radula relative size

Mean RL/SL ratios for *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* reported in the literature for several coastal regions of Spain, France, Great Britain and Ireland display the following ranges: 1.60-2.20, 0.94-1.20, 1.29-2.29, respectively (FISHER-PIETTE, 1934, 1935, 1941, 1948, EVANS, 1947, 1953, 1958; BRIAN AND OWEN, 1952; FISHER-PIETTE AND GAILLARD, 1959; CHRISTIAENS, 1973; IBAÑEZ, 1982; FELIU AND IBAÑEZ, 1984). Mean RL/$^3\sqrt{}$(SV) ratios for *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* in several coastal regions of Spain, France, and Great Britain show the following variation: 4.66-4.71, 2.87-2.90, 3.90-4.38, respectively (Fisher-Piette, 1941, 1948). Our results for Póvoa de Varzim (northwest Portugal) (Table III) were within, or very near these ranges.

P. ulyssiponensis is usually the least variable of these three limpets, if we consider the inter-site and within-site variability of the radula relative size (FISHER-PIETTE, 1934, 1935, 1941, 1948, EVANS, 1953, 1958; IBAÑEZ, 1982; FELIU AND IBAÑEZ, 1984). This conclusion is illustrated by data reported by IBAÑEZ (1982), IBAÑEZ AND FELIU (1983) and FELIU AND IBAÑEZ (1984) on several *Patella* species in the Basque coast. RL/SL ratios were determined at several sites in this region, and on different months and different levels, at each site. *P. ulyssiponensis* displayed similar RL/SL ratios along the year and between different levels in the beach. On the contrary, RL/SL ratios for *P. intermedia* and *P. vulgata* varied appreciably along the year, between sites and between different levels at each site. Generally, RL/SL ratios increased from winter to summer months. Our results for these species in Póvoa de Varzim agree with this conclusion. The coefficient of variation for the means of all variables describing the radula relative size were lowest in *P. ulyssiponensis*.

Data reported in the literature indicate that in the genus *Patella*, the radula relative size decreases, with lowering the level of the occurrence of the animal in the shore. This general trend has been observed both within each species, and between several species. BRIAN AND OWEN (1952) studied the variability of the RL/SL ratio for *P. vulgata* in the west coast of Great Britain. Whilst animals from high-water habitats, above high-water neaps, displayed RL/SL ratios in the range 1.83-1.96, animals from low-water habitats, about or below low-water neaps, showed RL/SL ratios between 1.38-1.61. DAVIES (1969) observed that in two sites in the Italian coast, intertidal populations of *Patella caerulea* Linné 1758 displayed longer radula than submerged populations. SELLA (1976) studied the variability of the RL/SL and RL/SH ratios in *Patella aspera* Röding 1798 (synonym *P. ulyssiponensis*) and *P. caerulea* from several Mediterranean stations in the Tyrrhenian Sea. In both species, both ratios decreased from animals living in the mesolittoral zone (50 cm above to 50 cm below water level) to animals living in the infralittoral region (6 to 26 m depth). In *P. ulyssiponensis*, the RL/SL ratio decreased, from the mesolittoral to the infralittoral zones, from 0.80 to 0.66 at one station, and from 0.90 to 0.64 at another site. The RL/SH ratio decreased from 3.2 to 3.0 and from 3.4 to 3.0, at the same sites and depths, respectively. Our observations that radula relative size was more variable than shell form, could have been due to this dependence of the radula relative size on the position of the animal in relation to the water level, since the animals were collected from the low shore to high shore levels, and all specimens of each species analysed as a unique set. However, the coefficient of variation of mean RL/SL and RL/$^3\sqrt{}$(SV) ratios was at maximum 20 %, a measure of variability not uncommonly found in biological populations. The exact extent of the variability of the radula relative size is expected to vary between sites in the European coasts, considering the polymorphism of the shorelines and the variability of tides in this area.

IBAÑEZ (1982) and IBAÑEZ AND FELIU (1983) found that in the Basque Coast, *Patella rustica* Linné 1758, *P. vulgata*, *Patella depressa* Pennant 1777 (synonym *P. inter-*

media) and *P. aspera* (*P. ulyssiponensis*) occupy successively lower positions in the coast. Mean RL/SL ratios for these species were 3.32, 1.76, 1.60-2.18, 0.986, respectively. HERNÁNDEZ-DORTA (1992) reported that in the Canary Islands, *Patella candei* d'Orbigny 1840, *Patella piperata* Gould 1846, *P. ulyssiponensis* and *Patella crenata* Gmelin 1791 (synonym *P. ulyssiponensis*) habitats decreased in height in the shoreline. Mean RL/SL ratios found for these species in the region were 1.63, 2.29, 0.74 and 1.12, respectively. This general trend of decreasing radula size from mesolittoral to the infralittoral species has also been found at Póvoa de Varzim. *P. ulyssiponensis* occupies the lowest positions in the shore, and displayed the lowest RL/SL and RL/$\sqrt[3]{(SV)}$ ratios.

III. Discrimination between species

Our results presented in this work showed that, in the discrimination between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim, variables describing the radula relative size were more important than variables describing shell form. Whilst using only variables related to shell form, the mean *a posteriori* correct identification to species was 65.0 %, using only variables describing the radula relative size this value rose to 75.7 %. Our results therefore confirm the observations reported by several malacologists (see Introduction) on the importance of the characteristics of the radula to the discrimination between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata*.

The RL/SL ratio is considered the most important morphometric variable for discriminating European *Patella* species. HERNÁNDEZ-DORTA (1992) comparing *P. candei*, *P. piperata* and *P. ulyssiponensis* from the Canary Islands concluded that, from several shell and radular variables, RL/SL was the most discriminating variable, followed by SH/SL. However, in the present work, for the discrimination between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim, the most important variable was RL/SH, both in the analysis using only radula relative size variables and in the analysis using both shell form and radula size variables. RL/$\sqrt[3]{(SV)}$ was the variable with the second highest loading, and RL/SL the third. This is a new finding, and can be due to the use, in the present analysis, of a wider range of variables describing the radula relative size, four instead of one or two commonly used. Alternatively, our results can be related to a specificity of these species at this site.

This observation that RL/SH was the most discriminating variable between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* confirms other results also found in this study on the importance of the SH in the discrimination between these species. Using only variables describing shell form, SH/SL was the most discriminating variable. Whilst slopes of the regressions, SW or SAA *vs.* SL were not statistically different, slopes of log SH *vs.* SL regression lines were significantly different.

The best discrimination between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim was achieved by using shell form and radula relative size variables. However, the overall mean correct identification to species (using *a priori* or *a posteriori* probabilities) was below 80 %, and only *P. ulyssiponensis* specimens were correctly identified in high percentage (higher than 95 %). It appears therefore that quantitative characters related to shell form and radula size are relatively poor discriminators between *P. intermedia* and *P. vulgata*. Qualitative characters are thus still indispensable for the discrimination between these two *Patella* species. Very good qualitative discriminators were, for *P. intermedia*, the tall and broad cusp 2 and the dark marginal rays in the shell interior surface, and for *P. vulgata*, the pointed protuberance on cusp 3, and the silvery head scar.

IV. The use of Canonical Discriminant Analysis in the discrimination between *Patella* species

Canonical discriminant analysis has been used in the literature to compare

limpet species. These analyses have used variables describing the shell and the radula - shell size and radula *absolute* size variables alone, or simultaneously, with shell form and radula relative size variables, which were the variables exclusively used in the present work. The use of variables describing shell and radula *absolute* sizes in the comparison between limpet species has however some limitations, because limpets present extremely variable populations structure. LEWIS AND BOWMAN (1975) and THOMPSON (1980) reported detailed studies on the biology and population dynamics of *P. vulgata* in several sites of the England and Ireland coasts. Very marked differences in length-frequency distributions were observed between populations occupying different tidal levels and different habitats. GUERRA AND GAUDENCIO (1986) studied several populations of *P. aspera* (*P. ulyssiponensis*), *P. depressa* (*P. intermedia*) and *P. vulgata* from the Portuguese coast, with monthly sampling. All these three species exhibited marked variations in the population structure throughout the year, and at a given month, these limpets showed different populations structures. These differences in populations structures have been interpreted as the result of a complex set of factors - gonad cycles, spawning and settlement periods, growth rates, survival, mortality and longevity, or in brief, as the result of population history (LEWIS AND BOWMAN, 1975; THOMPSON, 1980; GUERRA AND GAUDENCIO, 1986). Therefore, unless the populations that are compared have similar structures, namely percentage of juveniles and adults, and sampling is exhaustive and based on representatives of all age-classes, comparisons between variables describing shell and radula *absolute* sizes might not represent real differences between species.

CONCLUSIONS

P. intermedia, *P. ulyssiponensis* and *P. vulgata* from Póvoa de Varzim region have different shell growing patterns.

The best discrimination between *P. intermedia*, *P. ulyssiponensis* and *P. vulgata* was achieved by using shell form and radula relative size variables. However, whereas correct identification of *P. ulyssiponensis* specimens was higher than 95 %, the identification of *P. intermedia* and *P. vulgata* specimens ranged from 70 to 80 %. Qualitative characters describing the radula and the shell are thus still indispensable for the discrimination between these two limpet species.

Morphometric characteristics such as those utilized in this work are probably useful for characterization of *P. ulyssiponensis* as a species, but are of limited value for *P. intermedia* and *P. vulgata*.

ACKNOWLEDGEMENTS

I'm indebted to Dr. João Manuel Martins for helpful discussions and comments on the manuscript.

BIBLIOGRAPHY

BRIAN, M. V. AND OWEN, G., 1952. The relation of the radula fraction to the environment in *Patella*. *Journal of Animal Ecology*, 21: 241-249.

CHRISTIAENS, J., 1973. Révision du genre *Patella* (Mollusca, Gastropoda). *Bulletin du Muséum National d'Histoire Naturelle*, 182: 1305-1392.

DAVIES, S. P., 1969. Effect of environment on metabolic activity and morphology of Mediterranean and British species of *Patella*. *Pubblicazioni della Stazione Zoologica di Napoli*, 37: 641-656.

ESLICK, A., 1940. An ecological study of *Patella* at Port St. Mary, Isle of Man. *Proceedings of the Linnean Society of London*, 152: 45-54.

EVANS, R. G., 1947. Studies in the biology of British limpets. I. The genus *Patella* in Cardigan Bay. *Proceedings of the Zoological Society of London*, 117: 411-423.

EVANS, R. G., 1953. Studies in the biology of British limpets – the genus *Patella* on the south coast of England. *Proceedings of the Zoological Society of London*, 12: 357-376.

EVANS, R. G., 1958. The genus *Patella* on the west coast of France. *Journal de Conchyliologie*, 98: 126-150.

FELIU, J. AND IBAÑEZ, M., 1984. Sistematica y ecologia del genero *Patella* en la Costa Vasca: III. *Lurralde*, 7: 161-170.

FISCHER-PIETTE, M. E., 1934. Remarques de systématique et de biogéographie sur les Patelles des cotes françaises. *Bulletin du Muséum National d'Histoire Naturelle*, 6: 280-285.

FISCHER-PIETTE, E., 1935. Systématique et biogéographie. Les Patelles d'Europe et d'Áfrique du Nord. *Journal de Conchyliologie*, 79: 5-66.

FISCHER-PIETTE, E., 1941. Observations biométriques sur les Patelles de la Manche. *Journal de Conchyliologie*, 84: 300-306.

FISCHER-PIETTE, E., 1948. Sur les éléments de prospérité des Patelles et sur leur specificité. *Journal de Conchyliologie*, 88: 45-96.

FISCHER-PIETTE, E., 1966. Essai comparatif sur l´écologie des variétés de qualques mollusques côtiers. *Bulletin du Muséum National d'Histoire Naturelle*, 38: 656-668.

FISCHER-PIETTE, E. AND GAILLARD, J.-M., 1959. Les Patelles, au long des cotes atlantiques ibériques et nord-marocaines. *Journal de Conchyliologie*, 99: 135-200.

GUERRA, M. T. AND GAUDENCIO, M. J., 1986. Aspects of the ecology of *Patella* spp. on the Portuguese coast. *Hydrobiologia*, 142: 57-69.

HERNÁNDEZ-DORTA, F. J., 1992. Revisión del género *Patella* Linné, 1758 (Mollusca, Gastropoda) en las Islas Canarias. *Vieraea*, 21: 109-135.

IBAÑEZ, M., 1982. Sistema y ecologia del genero *Patella* en la Costa Vasca: I. *Lurralde*, 5: 69-78.

IBAÑEZ, M. AND FELIU, J., 1983. Sistematica y ecologia del genero *Patella* en la Costa Vasca: II. *Lurralde*, 6: 191-201.

LEWIS, J. R. AND BOWMAN, R. S., 1975. Local habitat-induced variations in the population dynamics of *Patella vulgata* L. *Journal of Experimental Marine Biology and Ecology*, 17: 165-203.

LINDBERG, D. R., 1982. A multivariate study of morphological variation of the limpet *Notoacmea depicta* (Hinds) and its synonyms *Notoacmea gabatella* (Berry) and *Notoacmea lepisma* (Bery) (Gastropoda: Acmaeidae). *Bulletin of the Southern California Academy of Sciences*, 81: 87-96.

MUÑOZ, M. A. AND ACUÑA, J. D., 1994. On the taxonomic discrimination between *Patella aspera* Röding and *P. caerulea* Linnaeus (Gasteropoda: Patellidae) using conchological traits. *Journal of Conchology*, London, 35: 37-43.

POWELL, A. W. B., 1973. The Patellid limpets of the world (Patellidae). *Indo-Pacific Mollusca*, 3: 551-768.

RAMPAL, J., 1965. Utilisation des dents radulaires pour la systématique des Patelles méditerranéennes. *Revue des Travaux de l'Institut des Pêches Maritimes*, 29 : 205-210.

ROLÁN, E., 1993. *Guía Ecolóxica das Cunchas e Moluscos de Galicia*. Edicións Xerais de Galicia, Vigo, 196 pp.

ROLÁN, E. AND OTERO-SCHMITT, J., 1996. *Guía dos Moluscos de Galicia*. Editorial Galáxia, Vigo, 318 pp.

SELLA, G., 1976. Biometrical relationships between mesolittoral and infralittoral *Patella* populations in the Mediterranean. *Pubblicazioni della Stazione Zoologica di Napoli*, 40: 123-132.

SIMISON, W. B. AND LINDBERG, D. R., 1999. Morphological and molecular resolution of a putative cryptic species complex: a case study of *Notoacmea fascicularis* (Menke, 1851) (Gastropoda: Patellogastropoda). *Journal of Molluscan Studies*, 65: 99-109.

THOMPSON, G. B., 1980. Distribution and population dynamics of the limpet *Patella vulgata* L. in Bantry Bay. *Journal of Experimental Marine Biology and Ecology*, 45: 173-217.

ZAR, EJ. H., 1984. *Biostatistical Analysis*. Prentice-Hall, New Jersey, 718 pp.

© Sociedad Española de Malacología —————— *Iberus*, 21 (2): 19-27, 2003

Toxic effect of *Thevetia peruviana* and *Alstonia scholaris* latices on the freshwater snail *Lymnaea acuminata*

Toxicidad de los látex de *Thevetia peruviana* y *Alstonia scholaris* sobre el molusco dulceacuícola *Lymnaea acuminata*

Sunil Kumar SINGH* and Ajay SINGH*[1]

Recibido el 4-X-2002. Aceptado el 21-I-2003

ABSTRACT

The aqueous and partially purified latex extracts of plants *Thevetia peruviana* and *Alstonia scholaris* (Family Apocynaceae) have potent molluscicidal activity. Sub-lethal doses of aqueous and partially purified latex extracts of both the plants also significantly alter the levels of total protein, total free amino acid, nucleic acid (DNA and RNA) and the activity of enzyme protease, acid and alkaline phosphatase in nervous tissue of the snail *Lymnaea acuminata* in time and dose dependent manner. The biologically active compounds present in *Thevetia peruviana* plant are Apigenine (Flavonoid) and triterpenoid glycosides, while a number of alkaloids (i.e. pseudo-akuammigine, Betulin, Ursolic acid and ß-sitosterol etc.), steroids and triterpenoids are present in *Alstonia scholaris* plant.

RESUMEN

Los extractos de latex acuosos y parcialmente purificados de las plantas *Thevetia peruviana* y *Alstonia scholaris* (Familia Apocynaceae) tienen potente actividad molusquicida. Dosis subletales de dichos extractos alteran significativamente los niveles de proteínas totales, aminoácidos libres, ácidos nucléicos y actividad de los enzimas proteasa, fosfatasa ácida y alcalina en el tejido nervioso de *Lymnaea acuminata* de manera tiempo-dependiente y dosis-dependiente. Los componentes activos de *Thevetia peruviana* son Apigenina (Flavonoide) y glicósidos triterpenoides, mientras que en *Alstonia scholaris* aparecen un cierto número de alcaloides (i.e. pseudo-akuammigina, betulina, ácido ursolico y ß-sitosterol entre otros), esteroides y triterpenos.

KEY WORDS: *Lymnaea acuminata, Thevetia peruviana, Alstonia scholaris*, metabolism.
PALABRAS CLAVE: *Lymnaea acuminata, Thevetia peruviana, Alstonia scholaris*, metabolismo.

INTRODUCTION

The use of synthetic or petroleum based molluscicides for controlling vector snails cause serious environmental pollution (MIAN AND MULLA, 1992; REDINGER, 1976; SUSAN, VEERAIAH AND TILAK, 1999). To overcome the problem and to search for eco-friendly molluscicides, a number of extracts and essential

* Natural Products Laboratory, Department of Zoology, D.D.U. Gorakhpur University, Gorakhpur-273 009 (UP), INDIA E- mail: ajay_s@sancharnet.in
[1] Corresponding Author

oils and their isolates have been evaluated for use as molluscicides due to their high toxicity, easy availability and easy biodegradability (MARSTON AND HOSTETTMANN, 1985; KINGHORN AND EVANS, 1975; SINGH, SINGH, MISRA AND AGARWAL, 1996). These materials have shown encouraging results for vector controlling properties with various snail species.

Thevetia peruviana and *Alstonia scholaris*, are common medicinal plants of family Apocynaceae. The latex of *Thevetia peruviana* is used in teeth cavities for relief from toothache and the latex of *Alstonia scholaris* is applied to ulcer, sores, tumers and rheumatic pain and is used for curing toothache (RAMA RAO, 1967). Both the plants have potent molluscicidal and anti-cholinesterase activity against harmful snails and slugs (PANIGRAHI AND RAUT, 1994; SINGH, YADAV AND SINGH, 2000; SINGH AND SINGH, 2002). The mechanism by which the active compounds present in both the plants causes snail death is not known.

The toxicological actions of *Thevetia peruviana*, may be due to the presence of apigenin-5-methyl ether (flavonoid) and triterpenoid glycosides (VOIGTLANDER AND BALSAM, 1970) while a number of alkaloids (pseudo-akuammigine in addition to betulin, ursolic acid and ß-sitosterol), steroids and triterpenoids are present in *Alstonia scholaris* (BANERJI AND BANERJI, 1977).

We are interested in knowing the mode of action and long-term effect of these plant products on snails, because these substances cannot be put to commercial use without a study of these aspects as well. In the present study, the effect of sub-lethal doses of aqueous and partially purified latex extracts of *Thevetia peruviana* and *Alstonia scholaris* is examined on nitrogenous metabolism of freshwater snail *Lymnaea acuminata*. This snail is intermediate host of liver fluke *Fasciola hepatica* and *Fasciola gigantica*, which causes endemic fascioliasis in cattle and live- stock in northern parts of India (SINGH AND AGARWAL, 1981).

MATERIALS AND METHODS

Latex of *Thevetia peruviana* and *Alstonia scholaris* were collected from Botanical garden of D.D.U. Gorakhpur University, Gorakhpur, India. White latex produced by these plants was drained into glass tubes fallowing cutting of the stem apices and lyophilised at –40°C and the lyophilised dry powder was used for further study. The wet weight of one ml of latex of *Thevetia peruviana* and *Alstonia scholaris* was 820 mg and 1000 mg and dry weight was 340 mg and 400 mg, respectively.

For aqueous extracts: The freeze-dried powder was mixed with appropriate volume of distilled water to obtain the desired concentrations.

For partial purification: The lyophilised latex powder was extracted sequentially with 5 mL each of chloroform → carbon tetrachloride → acetone → diethyl ether → ethyl alcohol. Centrifugation for 20 min at 2000 g was carried out in a refrigerated centrifuge, at -4°C, after each extraction. The solvent fraction was decanted and the solvent allowed to evaporates. The dried up soluble fraction was re-dissolved in water for further experiments.

Adult snail *Lymnaea acuminata* (2.6±0.3 cm in shell height) was collected locally and used as test animals. The snails were maintained and treated with aqueous and partially purified extracts of latices of the test plants according to SINGH AND AGARWAL (1990). Adult *Lymnaea acuminata* were kept in glass aquaria containing 3 litres of de-chlorinated tap water. Each aquarium contained 20 experimental animals.

Treatment protocol for dose- response relation

Snails were exposed for 24h or 96h to 40% and 80% of LC_{50} doses of *Thevetia peruviana* and *Alstonia scholaris* latices. LC_{50} doses were determined in an earlier study by SINGH (2000). The 24h or 96h doses for *Thevetia peruviana* were, respectively, 0.43 mg/L and 0.17 mg/L and for *Alstonia scholaris* were 4.76 mg/L and 1.76 mg/L.

After completion of treatment the test animals were removed from the aquaria and washed with water. The nervous tissue of *Lymnaea acuminata* was excised and used for biochemical analysis. Control animals were held in similar conditions without any treatment. Each experiment was replicated at least six times and the values have been expressed as mean ±SE of six replicates. Student's 't' test and analysis of variance were applied to locate significant changes (SOKAL AND ROHLF, 1973).

Biochemical estimation

Protein: Protein levels were estimated according to the method of LOWRY, ROSEBROUGH, FARR AND RANDALL (1951) using bovine serum albumin as standard. Homogenates (5 mg/mL, w/v) were prepared in 10% Trichloroacetic acid (TCA).

Total free amino acids: Estimation of total free amino acid was made according to the method of SPICES (1957). Homogenates (10 mg/mL, w/v) were prepared in 95% ethanol, centrifuged at 6000 g and used for amino acid estimation.

Nucleic acids: Estimation of nucleic acid (DNA and RNA) was performed, by the methods of SCHNEIDER (1957) using diphenylamine and orcinol reagents, respectively. Homogenates (1 mg/mL, w/v) were prepared in 5% TCA at 90°C, centrifuged at 5000 g for 20 min and supernatant was used for estimation of nucleic acids.

Protease: Protease activity was estimated by the method of MOORE AND STEIN (1954). Homogenate (50 mg/mL, w/v) was prepared in cold distilled water. Optical density was measured at 570 nm. The enzyme activity was expressed in m moles of tyrosine equivalent/mg protein/h.

Acid and alkaline phosphatase: The activity of acid and alkaline phosphatase in the nervous tissue was determined, according to the method of ANDERSCH AND SZCYPINSKI (1947) as modified by BERGMEYER (1967) and SINGH AND AGARWAL (1983). Tissue homogenates (2% w/v) were prepared in ice-cold 0.9% sodium chloride solution and centrifuged at 5000 g at (0°C) for 15 min. Optical density was measured at 420 nm against a blank, prepared simultaneously. The enzyme activity has been expressed as amount of ρ-nitrophenol formed/30min/mg protein in supernatant.

RESULTS

Data of sub-lethal (40% and 80% of LC_{50}) exposure of freshwater snail *Lymnaea acuminata* against aqueous and serially extracted latex of *Thevetia peruviana* and *Alstonia scholaris* for 24h and 96h on nitrogenous metabolism in nervous tissue *are* given in Table I-IV.

Thevetia peruviana

Exposure of snails to 40% and 80% of LC_{50} of aqueous latex extracts of *Thevetia peruviana* for 24h or 96h caused significant alterations in nitrogenous metabolism in nervous tissue of the freshwater snail *Lymnaea acuminata* (Table I-II). Total protein levels were reduced to 54% and 38% of controls, respectively after exposure to 40% and 80% of LC_{50} (24h) of aqueous latex extract. The maximum decrease in protein level (30 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. DNA level was reduced to 81% and 71% of controls after treatment with 40% and 80% of LC_{50} (24h), respectively. The maximum decrease in DNA (35 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. RNA level was reduced to 88% and 70% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue of *Lymnaea acuminata*. The maximum decrease in RNA (42 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. Total free amino acid levels were induced to 149% and 166% of controls after treatment with 40% and 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous tissue of snail *Lymnaea acuminata* (Table I-II).

Table I. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (µg/mg), protease (µg moles of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (µ mole substrate hydrolysed/30 min/mg protein) level in nervous tissue of *Lymnaea acuminata* after exposure to 40% and 80% of LC_{50} of aqueous and partially purified latex extracts of *Thevetia peruviana* for 24 h.

Tabla I. Cambios en los niveles de proteína total, aminoácidos libres, ácidos nucléicos (DNA y RNA) (µg/mg), proteasa (µg moles de equivalentes de tirosina/mg proteína/h) y fosfatasas ácida y alcalina (µ moles sustrato hidrolizado/30 min/mg proteína) en el tejido nervioso de Lymnaea acuminata *tras 24 h de exposición a extractos acuosos y parcialmente purificados de latex de* Thevetia peruviana *al 40% y 80% de LC_{50}.*

	Nature of latex	Control	40% of LC50	80% of LC50
Protein	A	65.00±0.28 (100)	34.80±0.36+ (54)	24.50±0.38+ (38)
	B	65.30±0.78 (100)	35.50±0.68+ (54)	27.50±0.84+ (42)
Amino acid	A	34.60±0.36 (100)	48.50±0.68+ (140)	45.60±0.76+ (152)
	B	34.40±0.65 (100)	51.20±0.77+ (137)	47.50±1.02+ (146)
DNA	A	75.40±1.02 (100)	60.90±0.88+ (81)	53.70±0.70+ (71)
	B	75.60±1.12 (100)	62.80±1.02+ (83)	55.50±1.05+ (73)
RNA	A	60.10±0.52 (100)	52.80±0.60+ (88)	42.06±0.52+ (70)
	B	61.20±0.82 (100)	54.60±0.70+ (88)	44.05±0.96+ (72)
Protease	A	0.325±0.067 (100)	0.378±0.052+ (116)	0.420±0.048+ (129)
	B	0.325±0.046 (100)	0.375±0.062+ (115)	0.415±0.062+ (128)
Acid phosphatase	A	0.193±0.0005 (100)	0.171±0.0004+ (89)	0.148±0.0003+ (77)
	B	0.193±0.0010 (100)	0.178±0.0003+ (92)	0.152±0.0006+ (79)
Alkaline phosphatase	A	0.381±0.0015 (100)	0.338±0.0006+ (89)	0.251±0.0005+ (66)
	B	0.382±0.0012 (100)	0.344±0.0005+ (90)	0.254±0.0003+ (66)

Values are mean ±SE of six replicates
Values in parenthesis are % change with control taken as 100%
+, Significant ($P<0.05$) student's 't' test was applied between control and treated groups
A – Supernatant of aqueous solution of latex
B – Latex serially extracted through chloroform, carbon tetrachloride, acetone, diethyl ether and ethyl alcohol

Activity of acid phosphatase was inhibited to 89% and 77% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue of snail. Activity of alkaline phosphatase was reduced to 89% and 66% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue of snail. The maximum decrease in acid and alkaline phosphatase 37 % and 45% of controls, respectively, was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. Protease activity was increased to 116% and 129% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in the nervous tissue of snail *Lymnaea acuminata*. The maximum increase in protease activity (141% of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract (Table I-II).

Latex was sequentially extracted with organic solvents also caused a similar alteration in nitrogenous metabolism of snail. Alterations caused by

Table II. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (μg/mg), protease (μg moles of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (μ mole substrate hydrolysed/30 min/mg protein) level in nervous tissue of *Lymnaea acuminata* after exposure to 40% and 80% of LC_{50} of aqueous and partially purified latex extracts of *Thevetia peruviana* for 96 h.
Tabla II. Cambios en los niveles de proteína total, aminoácidos libres, ácidos nucléicos (DNA y RNA) (μg/mg), proteasa (μg moles de equivalentes de tirosina/mg proteína/h) y fosfatasas ácida y alcalina (μ moles sustrato hidrolizado/30 min/mg proteína) en el tejido nervioso de Lymnaea acuminata *tras 96 h de exposición a extractos acuosos y parcialmente purificados de latex de* Thevetia peruviana *al 40% y 80% de LC_{50}.*

	Nature of latex	Control	40% of LC50	80% of LC50
Protein	A	68.50±0.48 (100)	30.50±0.44+ (44)	20.80±0.44+ (30)
	B	68.40±0.76 (100)	31.60±0.72+ (46)	21.60±0.48+ (32)
Amino acid	A	35.30±0.98 (100)	52.50±0.26+ (149)	58.60±0.36+ (166)
	B	35.30±0.98 (100)	40.50±0.46+ (143)	56.70±0.78+ (161)
DNA	A	72.16±0.93 (100)	39.50±0.46+ (55)	25.20±0.39+ (35)
	B	72.20±0.05 (100)	40.40±0.78+ (56)	28.30±0.98+ (39)
RNA	A	62.50±1.02 (100)	36.40±0.45+ (58)	26.45±0.78+ (42)
	B	62.80±1.12 (100)	38.50±0.78+ (61)	28.35±0.98+ (45)
Protease	A	0.345±0.058 (100)	0.420±0.072+ (122)	0.186±0.025+ (141)
	B	0.346±0.068 (100)	0.418±0.075+ (121)	0.128±0.032+ (138)
Acid phosphatase	A	0.192±0.0003 (100)	0.096±0.0005+ (50)	0.071±0.0006+ (37)
	B	0.191±0.0004 (100)	0.101±0.0007+ (53)	0.074±0.0011+ (39)
Alkaline phosphatase	A	0.400±0.0007 (100)	0.187±0.0010+ (47)	0.181±0.0007+ (45)
	B	0.390±0.0015 (100)	0.194±0.0004+ (50)	0.184±0.0004+ (47)

Details are as given in Table I

sequentially extracted latex, though statistically in significant, appeared lower than the water extracted latex at all the doses and exposure periods (Table I-II).

Alstonia scholaris

Exposure of snails to 40% and 80% of LC_{50} of aqueous latex extracts of *Alstonia scholaris* for 24h or 96h caused significant alterations in nitrogenous metabolism in nervous tissue of the freshwater snail *Lymnaea acuminata* (Table III-IV). Total protein levels were reduced to 55% and 40% of controls, respectively after exposure to 40% and 80% of LC_{50} (24h) of aqueous latex extract. The maximum decrease in protein level (35 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. DNA level was reduced to 85% and 75% of controls after treatment with 40% and 80% of LC_{50} (24h), respectively. The maximum decrease in DNA (39 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. RNA level was reduced to 90% and 75% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue of *Lymnaea acuminata*. The maximum decrease in RNA (45 % of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract. Total free amino acid levels were induced to 145% and 160% of controls after treatment with 40% and 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous tissue of snail (Table III-IV).

Table III. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (µg/mg), protease (µg moles of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (µ mole substrate hydrolysed/30 min/mg protein) level in nervous tissue of *Lymnaea acuminata* after exposure to 40% and 80% of LC_{50} of aqueous and partially purified latex extracts of *Alstonia scholaris* for 24 h.

Tabla III. Cambios en los niveles de proteína total, aminoácidos libres, ácidos nucléicos (DNA y RNA) (µg/mg), proteasa (µg moles de equivalentes de tirosina/mg proteína/h) y fosfatasas ácida y alcalina (µ moles sustrato hidrolizado/30 min/mg proteína) en el tejido nervioso de Lymnaea acuminata *tras 24 h de exposición a extractos acuosos y parcialmente purificados de latex de* Alstonia scholaris *al 40% y 80% de* LC_{50}.

	Nature of latex	Control	40% of LC50	80% of LC50
Protein	A	66.20±0.56 (100)	36.50±0.76$^+$ (55)	26.60±0.98$^+$ (40)
	B	66.50±0.78 (100)	38.20±0.56$^+$ (57)	29.90±0.78$^+$ (45)
Amino acid	A	35.50±0.57 (100)	47.90±0.78$^+$ (135)	52.50±0.68$^+$ (148)
	B	36.20±0.56 (100)	47.80±1.05$^+$ (132)	52.50±0.68$^+$ (145)
DNA	A	74.80±1.05 (100)	63.60±0.54$^+$ (85)	56.10±0.58$^+$ (75)
	B	75.20±1.06 (100)	65.40±0.96$^+$ (87)	57.20±0.46$^+$ (76)
RNA	A	61.20±1.06 (100)	55.10±0.58$^+$ (90)	45.90±0.78$^+$ (75)
	B	60.10±0.54 (100)	54.70±0.82$^+$ (91)	46.30±1.02$^+$ (77)
Protease	A	0.335±0.072 (100)	0.382±0.061$^+$ (114)	0.422±0.065$^+$ (126)
	B	0.328±0.062 (100)	0.367±0.052$^+$ (112)	0.407±0.082$^+$ (124)
Acid phosphatase	A	0.192±0.0003 (100)	0.172±0.0004$^+$ (89)	0.148±0.0007$^+$ (77)
	B	0.192±0.0002 (100)	0.175±0.0004$^+$ (91)	0.150±0.0006$^+$ (78)
Alkaline phosphatase	A	0.400±0.0010 (100)	0.366±0.0005$^+$ (92)	0.302±0.0005$^+$ (76)
	B	0.400±0.0005 (100)	0.372±0.0012$^+$ (93)	0.308±0.0003$^+$ (77)

Details are as given in Table I

Activity of acid phosphatase was inhibited to 89% and 77% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue of snail. Activity of alkaline phosphatase was reduced to 92% and 76% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in nervous tissue. Protease activity was increased to 114% and 126% of controls after treatment with 40% and 80% of LC_{50} (24h) of aqueous latex extracts respectively in the nervous tissue of snail *Lymnaea acuminata*. The maximum increase in protease activity (140% of control) was observed in snails treated with 80% of LC_{50} (96h) of aqueous latex extract, respectively (Table III-IV).

Latex of *Alstonia scholaris* was sequentially extracted with organic solvents also caused a similar alteration in nitrogenous metabolism of snail. Alterations caused by sequentially extracted latex, though statistically in significant, appeared lower than the water extracted latex at all the doses and exposure periods (Table III-IV).

DISCUSSION

It is clear from the result described above that the treatment with sub-lethal doses of aqueous and partially purified latex extracts of *Thevetia peruviana* and *Alstonia scholaris*, significantly alter the level of total protein, total free amino

Table IV. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (µg/mg), protease (µg moles of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (µ mole substrate hydrolysed/30 min/mg protein) level in nervous tissue of *Lymnaea acuminata* after exposure to 40% and 80% of LC_{50} of aqueous and partially purified latex extracts of *Alstonia scholaris* for 96 h.

Tabla IV. Cambios en los niveles de proteína total, aminoácidos libres, ácidos nucléicos (DNA y RNA) (µg/mg), proteasa (µg moles de equivalentes de tirosina/mg proteína/h) y fosfatasas ácida y alcalina (µ moles sustrato hidrolizado/30 min/mg proteína) en el tejido nervioso de Lymnaea acuminata *tras 96 h de exposición a extractos acuosos y parcialmente purificados de latex de* Alstonia scholaris *al 40% y 80% de LC_{50}.*

	Nature of latex	Control	40% of LC50	80% of LC50
Protein	A	65.60±0.48 (100)	30.20±0.84^{+} (46)	22.90±0.78^{+} (35)
	B	66.20±0.58 (100)	31.80±0.96^{+} (48)	23.80±0.48^{+} (36)
Amino acid	A	35.60±0.76 (100)	51.60±0.88^{+} (145)	56.90±0.78^{+} (160)
	B	36.50±0.54 (100)	51.80±0.46^{+} (142)	57.30±0.66^{+} (157)
DNA	A	74.80±1.05 (100)	44.90±0.78^{+} (60)	29.20±0.48^{+} (39)
	B	75.60±1.08 (100)	46.90±0.78^{+} (62)	31.00±1.02^{+} (41)
RNA	A	60.10±0.74 (100)	36.10±0.74^{+} (60)	27.00±0.48^{+} (45)
	B	61.50±0.78 (100)	38.71±1.06^{+} (63)	29.00±0.48^{+} (47)
Protease	A	0.340±0.076 (100)	0.408±0.035^{+} (120)	0.476±0.076^{+} (140)
	B	0.338±0.066 (100)	0.399±0.067^{+} (118)	0.463±0.064^{+} (137)
Acid phosphatase	A	0.193±0.0005 (100)	0.094±0.0003^{+} (49)	0.074±0.1133^{+} (38)
	B	0.192±0.0008 (100)	0.099±0.0007^{+} (52)	0.072±0.0006^{+} (38)
Alkaline phosphatase	A	0.380±0.0007 (100)	0.188±0.0010^{+} (49)	0.145±0.00038^{+} (38)
	B	0.390±0.0007 (100)	0.195±0.0009^{+} (50)	0.148±0.0004^{+} (39)

Details are as given in Table I

acid and nucleic acid and activity of enzyme protease, acid and alkaline phosphatase. The rate of alteration in all the cases was significantly ($P<0.05$) time and dose dependent.

Proteins are mainly involved in architecture of the cell. During chronic periods of stress they are also a source of energy (UMMINGER, 1977). The decrease in protein level observed in this study may be due to their degradation and also to their possible utilization for metabolic purposes. BRADBURY, SYMONIC, COATS AND ATCHISON (1987) pointed out that the decrease protein content might also be attributed to the destruction or necrosis of cells and consequent impairment in protein synthesis machinery.

The quantity of protein depends on the rate of protein synthesis or its degradation. It also affected due to impaired in corporation of amino acids in to polypeptide chains (SINGH ET AL., 1996). The synthesis of RNA plays an important role in protein synthesis. The inhibition of RNA synthesis at transcription level, thus may affect the protein level. In this study, a significant decline in RNA level in exposed snail was observed. The decrease in RNA level may also have been a cause of protein depletion. On the other hand, increase in protease activity may be the cause of increased protein degradation.

Enhanced protease activity and decreased protein level have resulted in marked elevation of free amino acids

that in the snail tissue. The accumulation of free amino acids can also be attributed to the lesser use of amino acids (SESHAGIRI RAO, SRINIVAS, MOORTHY, SWAMY AND CHETHY, 1987) and their involvement in the maintenance of an acid-base balance (MOORTHY, KASHI REDDY, SWAMY AND CHETHY, 1984). NATARAJAN (1985) reported that stress condition in general induces elevation in the trans-amination pathway.

Extracts of both the plants also decreased the level of nucleic acids significantly in the nervous tissue of the snail. Several reports are available on the reduction in DNA and RNA level on exposure to different pesticides (TARIG, HAQUI AND ADHAMI, 1977; NORDENSKJOLD, SODERHALL AND MOLDEUS, 1979). Data attained in this study made it clear that these plant extracts are potential inhibitor of DNA synthesis, which resulted in the reduction in the RNA level. MAHENDRU (1981) suggested that the anti-AChE compounds attack many enzymes responsible for normal metabolism pathway. Thus it is possible that lattices of both the plants might have inhibited the enzymes necessary for DNA synthesis, because the lattices of both the plant tested in the present study have potent anti-AChE activity (SINGH AND SINGH, 2002).

VORBRODT (1959) has reported that alkaline phosphatase is an important enzyme of animal metabolism, which play an important role in the transport of metabolites a cross the membranes. Since, both the plants used in the present study may also have anti-phosphatases activity. So the reduction in protein level may be due to the inhibition of alkaline phosphatase activity, as it plays an important role in protein synthesis (PILO, ASNANI AND SHAH, 1972) and also involved in the synthesis of certain enzymes (SUMNER, 1965).

CONCLUSIONS

We therefore believe that these plant extracts may eventually be of great value for the control of aquatic target organisms, i.e. harmful vector snails and mosquito larvae.

ACKNOWLEDGEMENTS

One of the authors (Sunil Kumar Singh) is thankful to Department of Environment, (Ministry of Environment and Forest) Govt. of India (Sanction No. F-14/35/96 MAB-RE Dated: 09-11-1999), for financial support.

BIBLIOGRAPHY

ANDERSCH, M. A. AND SZCYPINSKI, A. J., 1947. The calorimetric determination of phosphatase in biological materials. *American Journal of Clinical Pathology*, 17: 571-574.

BANERJI, A. AND BANERJI, J., 1977. Isolation of Pseudo-akuammigine from the Leaves of *Alstonia scholaris* R. Br. *Indian Journal of Chemistry*, 15 (B): 390-391.

BERGMEYER, U. H., 1967. In: *Methods of Enzymatic Analysis*. Academic Press, New York, 1129 pp.

BRADBURY, S. P., SYMONIC, D. M., COATS, J. R. AND ATCHISON, G. J. 1987. Toxicology of fenvalerate and its constituents isomers to the fathead minnow (*Pimephales promelos*) and blue gill (*Leponis macrochinus*). *Bulletin of Environmental Contamination and Toxicology*, 38: 727-735.

KINGHORN, A. D. AND EVANS, F. J., 1975. A Biological screen of selected species of the genus *Euphorbia* for skin irritant effects. *Planta Medica*, 28: 325-335.

LOWRY, H. W., ROSEBROUGH, N. J., FARR, A. L. AND RANDALL, R. J., 1952. Protein measurement with folin phenol reagent. *Journal of Biological Chemistry*, 193: 265-275.

MAHENDRU, V. K., 1981. *Studies on Pharmacology of molluscicides on the gastropod* Lymnaea acuminata. Ph. D. thesis, Department of zoology, Gorakhpur University, Gorakhpur. India.

MARSTON, A. AND HOSTETTMANN, K., 1985. Plant mollusicicde. *Phytochemistry*, 24: 639-652.

MOORE, S. AND STEIN, W. H., 1954. A modified ninhydrine reagent for the photometric determination of amino acids and related compounds. *Journal of Biological Chemistry*, 211: 907-913.

MOORTHY, K. S., KASHI REDDY, B., SWAMY, K. S. AND CHETHY, C. S., 1984. Changes in respiration and ionic content in the tissues of fresh water mussel exposed to methyl-parathion toxicity. *Toxicological Letter*, 21: 287-291.

MIAN, L. S. AND MULLA, M. S., 1992. Effects of pyrethroid insecticides on non-target invertebrates in aquatic ecosystem. *Journal of Agricultural Entomology*, 9 (2): 73-98.

NATARAJAN, G. M., 1985. Inhibition of branchial enzymes in snakehead fish (*Channa striatus*) by oxy demetom-methyl. *Pesticide Biochemistry Physiology*, 23: 41-46.

NORDENSKJOLD, M., SODERHALL, J. AND MOLDEUS, P., 1979. Studies on DNA trand break induced in human fibroblast by chemical mutagens and carcinogens. *Mutational Research*, 63: 393-400.

PANIGRAHI, A. AND RAUT, S. K., 1994. *Thevetia peruviana* (family-Apocynaceae) in the control of slug and snail pests. *Memorias do Instituto Oswaldo Cruz Rio de Janerio*, 89 (2): 247.

RAMA RAO, K., 1967. *Poisonous Plants of India*. Vol. I: A, ICAR, New Delhi, 201 pp.

PILO, B., ASNANI, M. V. AND SHAH, R. V., 1972. Studies on wound healing and repair in pigeon liver: II. Histochemical studies on acid and alkaline phosphatase during the process. *Journal of Animal Morphology Physiology*, 19: 205-212.

REDINGER, R. F., 1976. Organochlorine residues in adults of six South – Western bat species. *Journal of Wild Life Management*, 40: 677-680.

SCHNEIDER, W. C., 1957. Determination of nucleic acids in tissue by pantose analysis. In Calowick, S. P. and Kaplon, N. O. (Eds.): *Methods of Enzymology*. Academic press, New York, pp., 680.

SESHAGIRI RAO, K., SRINIVAS MOORTHY, K., KASHI REDDY, B., SWAMY, K. S. AND CHETHY, C. S., 1987. Effect of benthiocarb on protein metabolism of teleost, *Sarotherodon mossambica*. *Indian Journal of Environmental Health*, 29: 440-450.

SINGH, A. AND AGARWAL, R. A., 1990. Molluscicidal properties of synthetic pyrethroids. *Journal of Medical and Applied and Malacology*, 2: 141-144.

SINGH, A., SINGH, D. K., MISRA, T. N. AND AGARWAL, R.A., 1996. Molluscicides of plant origin. *Biological Agricultural and Horticulture*, 13: 205-252.

SINGH, N. N., DAS, V. K. AND SINGH, S., 1996. Effect of aldrine on carbohydrate, protein and ionic metabolism of a freshwater catfish *Heteropneustes fossilis*. *Bulletin of Environmental Contamination and Toxicology*, 57: 204-210.

SINGH, O. AND AGARWAL, R. A., 1981. Toxicity of certain pesticides to two economic species of snails in Northern India. *Journal of Economic Entomology*, 74: 568-571.

SINGH, R. AND AGARWAL, R. A., 1983. Chemosterilization and its reversal in the snail *Lymnaea acuminata*. *Acta. Pharmacological Toxicological*, 52: 112-120.

SINGH, S. K., YADAV, R. P. AND SINGH, A., 2000. Molluscicidal activity of *Thevetia peruviana*, a common medicinal plant of India. Journal of. *Medicinal and Aromatic Plant Sciences*, Vol. 22/4A and 23/1A: 113-116.

SINGH, S. K., 2000. *Studies on molluscicidal properties of some local plants of eastern Uttar Pradesh against harmful snails*. Ph.D. thesis, D.D.U. Gorakhpur University, Gorakhpur (U.P.), India.

SINGH, S. K. AND SINGH, A., 2002. Effect of the plants *Thevetia peruviana* and *Alstonia scholaris* (family-Apocynaceae) and acetylcholinesterase activity of *Lymnaea acuminata*. *Egyptian Journal of Schistosomiasis and Infectious and Endemic Diseases*, Egypt, Vol.: 25 (In press).

SOKAL, R. R. AND ROHLF, F. J., 1973. *Introduction to Biostatistics*. MN Freeman, San Francisco, pp., 368.

SPICES, J. R., 1957. Colorimetric procedures for amino acids. In Calowick, S. P. and Kaplon, N. O. (Eds.): *Methods of Enzymology*. Academic press, New York, 468 pp.

SUMNER, A. T., 1965. The cytology and histology of the digestive gland cells of *Helix*. *Quaterly Journal of Microscopic Science*, 106: 173-192.

SUSAN, T., ANITA VEERAIAH, K. AND TILAK, K. S., 1999. A study on the bioaccumulation of fenvalerate a synthetic pyrethroid, in the whole body tissue of *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* (Ham.) by gas-liquid chromatography. *Pollution Research*, 18 (1): 57 – 59.

TARIG, S. S., HAQUI, M. AND ADHAMI, U. M., 1977. Effect of thioptera on RNA and total protein synthesis content in the testis of albino rats. *Indian Journal of Experimental Biology*, 15: 804-805.

UMMINGER, B. L., 1977. Relation of whole blood sugar concentration in vertebrate to standard metabolic rate. *Comparative Biochemistry Physiology*, 55: 457-460.

VOIGTLANDER, H. W. AND BALSAM, G., 1970. Apigenin 5-methyl ether, ein neues Flavon aus, *Thevetia peruviana*, *Archives and Pharmacology*, (Weinheim) 303: 792.

VORBRODT, A., 1959. The role of phosphatase in intracellular metabolism. *Postepy Higieny i Medycyny Doswiadczalnej*, 13: 200-206.

A sibling species of *Gibberula cordorae* (de Jong and Coomans, 1988) in the Leeward Antilles

Una especie gemela de *Gibberula cordorae* (de Jong and Coomans, 1988) en las Antillas de Sotavento

Franck BOYER*

Recibido el 13-XI-2002. Aceptado el 14-II-2003

ABSTRACT

The species *Gibberula cordorae* (de Jong and Coomans, 1988) is revised. Its distribution ranges from the type locality of Curaçao up to Saint-Vincent and Saint-Lucia. The morphologic variability of its shell is observed as being very low in Saint-Vincent and noticeably higher in Curaçao.

A sibling species, *Gibberula colombiana* sp. nov., is described from Martinique. Its distribution ranges up to eastern Guadeloupe. The morphologic variability of its shell is low, and shows more affinities with the population from Curaçao than with the Saint-Vincent's one.

The present distribution of these different populations is interpreted as resulting from distinct dispersion stages rather than from a continuous geographic cline.

RESUMEN

Se revisa la especie *Gibberula cordorae* (de Jong and Coomans, 1988). Su área de distribución incluye desde la localidad típica de Curaçao hasta Saint-Vincent y Saint-Lucia. La variabilidad morfológica de su concha ha sido observada siendo muy baja en Saint-Vincent y evidentemente alta en Curaçao.

Una especie gemela, *Gibberula colombiana* sp. nov., es descrita de Martinique. Su área de distribución llega hasta el este de Guadaloupe. La variabilidad morfológica de su concha es baja, y muestra más afinidad con la población de Curaçao que con la de Saint-Vincent.

La presente distribución de estas differentes poblaciones es interpretada como el resultado de distintos estados de dispersión más que como procedente de una variación clinal.

KEY WORDS: *Gibberula,* Lesser Antilles, sibling species, geographic dispersion, allopatric speciation, variability.
PALABRAS CLAVE: *Gibberula,* Antillas menores, especies gemelas, dispersión geografica, especiación alopátrica, variabilidad.

INTRODUCTION

The species *Gibberula cordorae* (de Jong and Coomans, 1988) was not recorded in the literature since its description on 19 shells collected at 30 m depth off Curaçao. Except for few additional material sampled in Curaçao by R. Moolenbeek (Zoologisch Museum Amsterdam) in the beginning of the

* 110, Chemin du Marais du Souci, 93270 Sevran, France.

heighties, the species remained perfectly elusive for many years in public and private collections.

During the second half part of the nineties, some few additional samples have been yielded from Curaçao by dutch collectors, and similar morphs have been discovered from Saint-Vincent to Guadeloupe by french collectors.

On the ground of these last findings, J. Colomb (pers. comm.) observed the constant occurrence of a brown patch on the columella of the shells from Saint-Vincent and Saint-Lucia, and the absence of such a patch on the shells from Martinique. By the fact of these divergent features and of contrasted ranges of length between both sets of shells, J. Colomb suggested that two allopatric species might be represented under the form *G. cordorae*, the population from Martinique constituting a sibling species new to the science.

Stimulated by such a suggestion, the revision of *G. cordorae* is conducted hereunder, and its variability is studied.The specific identity of the population ranging in Martinique is verified to be distinct and to deserve a description as a new species.

Gibberula cordorae was initially described as belonging to the genus *Persicula*. In fact, both genera are very close. They have the same kind of soft parts external anatomy with bifurcated dead, and their shells principally differ by the presence of a thick external labial margin bordered by a noticeable groove in the species attributed to *Persicula* (Boyer, Neefs and Wakefield, 1998).

Abbreviations

ad= adult, juv= juvenile, spm= live collected specimen, sh= dead collected shell, splg= sampling.
MNHN Muséum national d'Histoire naturelle, Paris.
ZMA Zoologisch Museum Amsterdam
FBC F. Boyer collection
JCC J. Colomb collection.

RESULTS

Family Cystiscidae Coovert and Coovert, 1995
Genus *Gibberula* Swainson, 1840

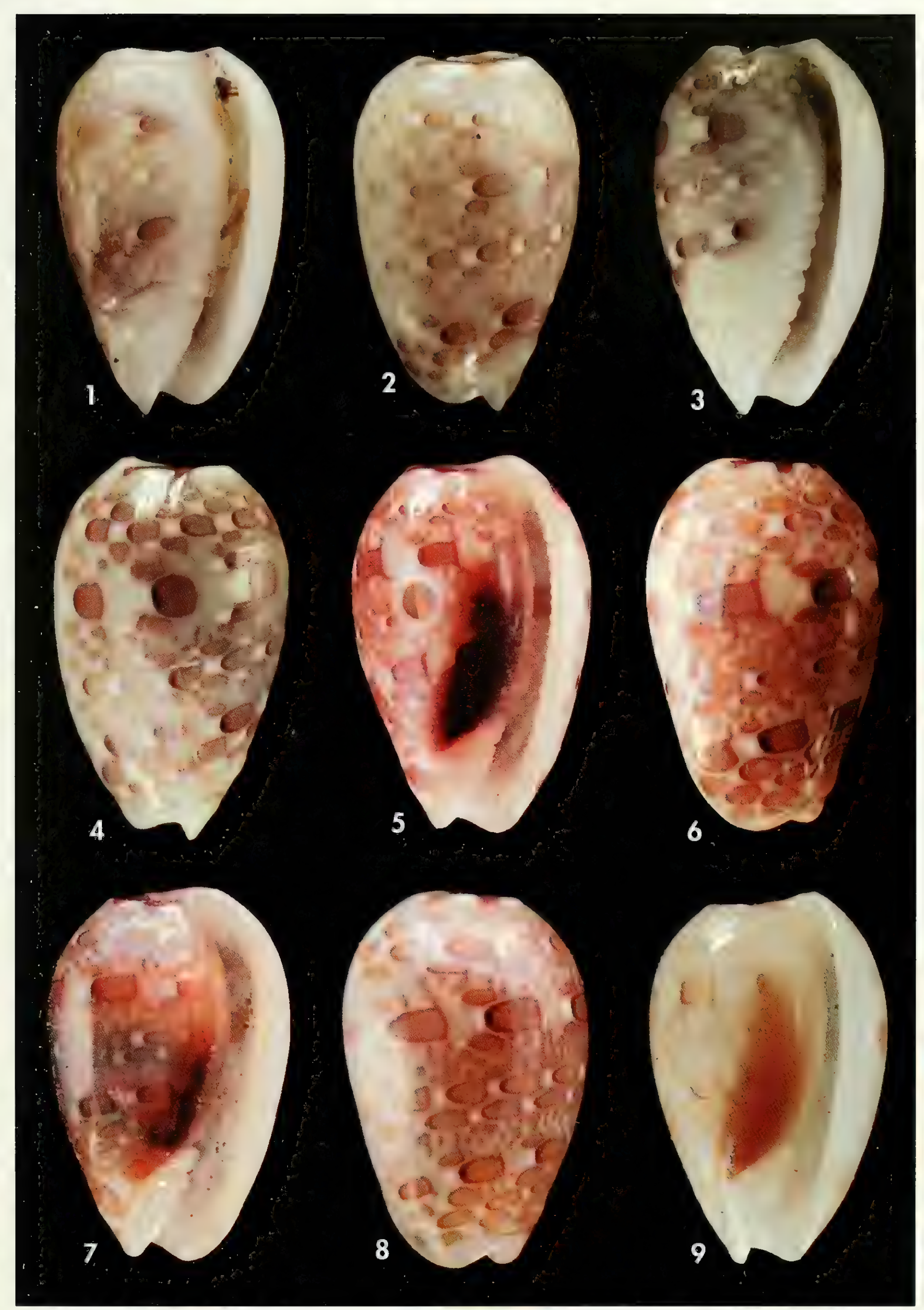
Type species: *Gibberula zonata* Swainson, 1840 by monotypy (=*Volvarina oryza* Lamark, 1822).

Gibberula cordorae (De Jong and Coomans, 1988) (Figs. 5-9, 10 A-C).

Persicula cordorae De Jong and Coomans, 1999, p. 99, pl. 41, figs. 543 A, B.

Type material: Holotype in ZMA (n° 3.87.093). Non studied.
Other material studied: 14 ad sh (L=5.05 to 6.10 mm), 27 juv and fragments, Saint Kruys Bay, Curaçao, 20-30 m, FBC, leg. J. Neefs (Breda, Netherland); 4 ad sh (L=5.70 to 6.30 mm),1 juv, Curaçao, 30-60 m, FBC; 1 ad spm (L=5 mm), 3 ad sh (L=5 to 5.30 mm), 3 juv, Curaçao, 6-10 m, FBC; 118 ad sh (L=3.85 to 5.15 mm),14 juv and fragments, Saint-Vincent, 30-40 m, J. Colomb splg 03-01, FBC; 21 ad sh (L=4.08 to 5.41 mm), Saint-Vincent, 30-40 m, J. Colomb splg 03-01, JCC (Figs. 5-8); 8 ad sh (L=4.51 to 5.22mm), Pigeon Island, Roadney Bay, Saint-Lucia, 2 m, J. Colomb splg 03-01, JCC (Fig. 9).
Type locality: Curaçao, Santa Martha, at a depth of 30 m.

Original description: "Shell small with a flat apex. Outer lip thickened and serrated on the inside. Last whorl smooth and shiny. The colour pattern consists of alternately 2 prominent and 3 much less prominent pattern-rows in spiral form. The 2 prominent rows each consist of 5 to 6 well separated figures. Each figure is built up of a large brown rectangle and next to this on both sides a much narrower brown rectangle. The figures in the three less prominent rows each



Figures 1-4. *Gibberula colombiana* sp. nov. 1, 2: holotype (MNHN), 6.0 x 3.8 mm; 3, 4: paratype 1 (CJC), 6.1 x 4.0 mm. Figures 5-9. *Gibberula cordorae* (De Jong and Coomans). 5, 6: Saint-Vincent, 40 m, 5.2 x 3.3 mm; 7, 8: Saint-Vincent, 40 m, 5.2 x 3.1mm; 9: Saint-Lucia, 10 m, 5.1 x 3.5 mm.
Figuras 1-4. Gibberula colombiana *sp. nov. 1, 2: holotype (MNHN), 6,0 x 3,8 mm; 3, 4: paratype 1 (CJC), 6,1 x 4,0 mm. Figuras 5-9.* Gibberula cordorae *(De Jong and Coomans). 5, 6: Saint-Vincent, 40 m, 5,2 x 3,3 mm;7, 8: Saint-Vincent, 40 m, 5,2 x 3,1mm; 9: Saint-Lucia, 10 m, 5,1 x 3,5 mm.*

count about 10 white squares and many brown squares, giving a pattern different from that of the prominent rows. The background is greyish".

Complementary description: On the ground of the specimens from Curaçao sampled in 20-30 m and 30-60 m, considered as topotypes and showing the same outline than the figured holotype (DE JONG AND COOMANS, 1988: figs. 543 AandB), further details can be added.

The apex can be more or less flat and wide, excavated or bulging, but generally it is submerged by enamel callus. In some cases, the suture of the last whorl makes a sharp elevation around the flattened spire and the top of the shell forms like a wide and shallow crater. Rarely, the coiling of the first whorls is suggested or partially visible. The place of the protoconch can be suggested where a more or less pronounced pit occurs on the flattened apex (Fig. 10 A).

A thin varix-shaped fold borders the edge of the labrum, enlarging progressively towards the base, and making a distinct oblique callus at the base of the ventral side, after bypassing the deep siphonal notch. About 30 very small denticles are visible on the inner lip. The 4 anterior columellar plaits are strong and arched (the first one being the larger), and followed by about 5 columellar lirations. The left basal keel is generally shorter than the right one, rarely reaching the same level.

The ground decoration consists of golden to chestnut-orange oval ocelles on a creamy-beige background (better than greyish as reported for the holotype) and crossed by 2 prominent and 3 fainter spiral rows of large chestnut-orange squares or rectangles with dark borders and separated by white intervals. The ground decoration of ocelles is often disintegrated in irregular dashes or spots, like it is visible in the holotype.

Among the 18 adult shells considered as topotypes, all but one show a large dark brown patch covering most of the external columella, from the level of the second plait to the third posterior quarter of the aperture. The development of this patch occurs in the subadult stage. This specific character is not represented in the holotype.

The shell outline is oval subpyriform. Animal unknown.

Measurements: Holotype: 6.5 x 3.7 mm (ZMA). Topotypes: L=5.05 to 6.30 mm (FBC).

Distribution: The species is known from Curaçao, Saint-Vincent and Saint-Lucia, mostly from 20 to 40 m.

J. Colomb remarked however (pers. comm.) that the material from Saint-Lucia consists of few dead shells from one sampling at only 2 m deep, within an anchorage where an artificial dyke was strengthened by the supply of sands brought from another place. Due to the facts that he did not find the species in other places along the western coast of Saint-Lucia, and that other "southern antillean species" (like *Conus aurantius* Hwass, 1792) were also found in dead conditions in the surrounding of the same artificial dyke, J. Colomb suggested that the lot of *G. cordorae* from Saint-Lucia may have been transported here by human industry.

The gap in the geographic distribution between Curaçao and Saint-Vincent is probably due to the lack of adequate sampling efforts at appropriate depths in this area.

Remarks: The morphology of the shell and its decoration do not show any remarkable variation along the distribution range of the species.

The population from Saint-Vincent is very homogeneous and shows faint differences with the topotypes from Curaçao: the shells from Saint-Vincent present a smaller average size, a more rounded shell, the apex being never fully crater-excavated with a central pit (Fig. 10 C), nor really bulging. The left basal keel is always shorter than the right one. The ground colour is honey to beige, decorated of large oval ocelles at both tips, which tend to disintegrate in a flecked pattern at the median part of the shell. The dark ventral patch is always present in adult and subadult from Saint-Vincent, even in very worn state.

The shells found in Saint-Lucia do not show any difference with the shells

from Saint-Vincent, except for the pattern of oval ocelles which do not tend to disintegrate in the small lot at hand.

It must be underlined that several of the features discussed here are very subtile, and their comparative study requires homogeneous conditions of observation and preservation. For instance, when ventral views of the shells are not perfectly taken in the plan, and when the aperture is slightly turned towards the left whereas the base is slightly carried towards the backside (as in Fig. 9), so the labrum seems to be thicker, the top wider and the left keel longer than in reality.

The topotypes from Curaçao show a higher variability in morphology, proportions and decoration, but the small lot coming from shallow water (6-10 m, 4 ad + 3 juv) show the most divergent features. The four adult shells have a slender subcylindric outline, the top is narrow, the top of the outer lip shows a clear tendency to encompass the apex (Fig. 10 B), the basal keels tend to reach the same level, and only one of the 4 adult shells shows the ventral brown patch. Their ground bottom is greyish rather than creamy-beige, and the pattern of small ground ocelles is very ill defined.

Gibberula colombiana sp. nov. (Figs. 1-4, 10 D).

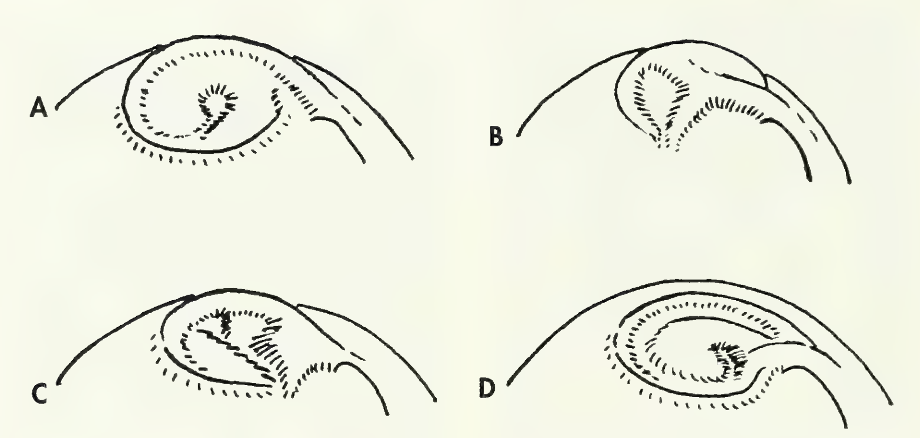
Type material: Holotype (Figs. 1, 2) in MNHN; 6 paratypes (Figs. 3, 4) (ad spm) in JCC; 4 paratypes (1 ad spm, 1 subad spm and 2 juv spm) in FBC; all from the type locality.
Other material studied: 6 ad sh (L=5 to 5.6 mm), Anse d'Arlet, Martinique, 30 m, F. Boyer and R. Delannoye splg 05-97, FBC; 1 ad sh (L=5.8 mm), 1 juv and 1 fragment, Cap Salomon, Martinique, 22-25 m, P. Clovel splg 28-06-97, FBC; 6 ad sh (L=5.4 to 6.2 mm), 6 juv, Cap Salomon, Martinique, 22-25 m, P. Clovel splg 12-08-97, FBC; 4 ad sh (L=4.9 to 5.7 mm), 5 juv, Cap Salomon, Martinique, 27 m, P. Clovel splg 29-08-97, FBC; 3 ad sh (L=5.4 to 5.9 mm), 1 juv, Cap Salomon, 30 m, P. Clovel splg 4-09-97, FBC; 1 ad spm (5.9 mm), 4 ad sh (L=5.15 to 5.40 mm), 43 juv, Cap Salomon, Martinique, 22-30 m, P. Clovel splg 6-09-97, FBC; 1 ad spm (L=5.6 mm), 4 juv, Anse d'Arlet, Martinique, 30 m, P. Clovel splg 10-98, FBC; 47 ad sh (L=5.42 to 6.27 mm), Grande Anse, Martinique, 20-25 m, J. Colomb splg 2001, JCC; 3 ad sh (L=5.35 to 5.70 mm),1 juv, Grande Anse, Martinique, 20-25 m, J. Colomb splg 2001, FBC; 1 ad sh, Guadeloupe, east coast, 15m, G. Paulmier splg and coll.
Type locality: Grande Anse, southwestern coast of Martinique, 20-25 m.
Etymology: From the name of Jacques Colomb (Marseilles, France), who first attracted the author's attention on the specificity of the population of *G.* cf. *cordorae* represented in Martinique.

Description: Shell medium-sized for the genus, outline oval subcylindric. The top is flat, wide and excavated, the suture of the last whorl making a sharp elevation around the spire, which partially reveals the coiling of the first whorls, slightly merged by enamel callus. The protoconch is suggested by a central pit.

The shoulder of the labrum is sharp and slightly elevated behind the top, the labrum is arched and thickened, and bears numerous tiny denticles almost obsolete on the upper part of the inner lip. A thin varix-shaped fold is bordering the edge of the labrum, enlarging progressively towards the base, encompassing the siphonal notch and making an oblique callus at the base of the columella. The 4 anterior columellar plaits are strong and arched, and followed by 5 columellar lirations. The left basal keel is much longer than the right one.

The ground decoration is made of orange-grey oval ocelles on a creamy-grey back, crossed by 2 prominent spiral rows of large honey-brown rectangles with dark borders and separated by white intervals. 3 fainter spiral rows of creamy-grey rectangles separated by white intervals are distributed on either sides of the 2 prominent spiral rows. Some of the ground ocelles are partially obsolete or divided in small spots and flecks. Any colour patch is not present on the columella.

Animal (from photos and drawings made by R Delannoye and J. Colomb): the wide foot is hyalinous covered of



Figures 10 A-C. *Gibberula cordorae* (De Jong and Coomans). A: Curaçao, 30-60 m; B: Curaçao, 6-10 m; C: Saint-Vincent, 40 m. Figure 10 D. *Gibberula colombiana* sp.nov., Martinique, 20-25 m.
Figuras 10 A-C. Gibberula cordorae *(De Jong and Coomans). A: Curaçao, 30-60 m; B: Curaçao, 6-10 m; C: Saint-Vincent, 40 m. Figure 10 D.* Gibberula colombiana *sp.nov., Martinique, 20-25 m.*

milky white large lateral patches (sometimes creamy white or light yellowish towards the posterior part) and by many smaller irregular spots more densely grouped on the front of the propodium and on the back axis of the metapodium. Few orange dots are scattered on the hyalinous ground and more densely grouped on the back axis of the metapodium. The bifurcate head and the siphon are milky white, with some orange dots around the eyes. The long hyalinous tentacles are decorated by whitish dashes and dots, and by scattered orange dots. The eyes are black.

Measurements: Holotype: 6 x 3.8 mm (MNHN). Paratypes 1 to 6, L=5.86 to 6.23 mm (JCC). Paratype 7 (ad.sh), L=5.9 mm, paratypes 8 to 10 (subad and juv.sh), L=4.9 to 5.5 mm (FBC).

Distribution: The species is known from Martinique by many individuals and from Guadeloupe by only one shell. This last one is absolutely similar to the material from southwest Martinique, and the datum given by G. Paulmier is confirmed as right. So the species must be ranging at least from Martinique to Guadeloupe, the extension of the distribution towards northern Lesser Antilles remaining possible on the ground of new discoveries.

Remarks: *G. colombiana* sp. nov shows very homogeneous shell morphology and decoration, and presents close similarity with *G. cordorae*. Most of the features represented in *G. colombiana* belong to the range of variability represented in the populations of *G. cordorae* from Curaçao. The large size and the excavated top of the shell of *G. colombiana* (Fig. 10 D) match the features occurring in several topotypes of *G. cordorae* (Fig. 10 A). The subcylindric outline and the greyish ground of decoration found in *G. colombiana* match the features of the shells of *G. cordorae* studied from shallow water in Curaçao (6-10 m).

However, two special characters can be considered as distinctive features of *G. colombiana*: the longer left basal keel and the total lacking of a ventral brown patch. The first character is especially original, as such a produced keel is very uncommon within the genus. The second character is significant from a statistic point of view, as the ventral patch is represented as highly dominant in *G. cordorae,* lacking only in few shells from Curaçao and never lack in the shells from Saint-Vincent and Saint-Lucia. The presence of a ventral patch can be considered as a specific feature of *G. cordorae,* accidentally absent (or much



Figure 11. Map of the Eastern Caribbean Sea.
Figura 11. Mapa del Este del Mar Caribe.

obsolete) in some shells, whereas the total lack of ventral patch in *G. colombiana* can be interpreted as a proper specific feature.

On the other hand, it must be underlined that the very homogeneous shell features of *G. colombiana* show many similarities with some of the forms of *G. cordorae* ranging in Curaçao, but much less with the populations from Saint-Vincent and Saint-Lucia which range in a closer vicinity. In these conditions, the neighbouring populations from Martinique on one hand and from Saint-Vincent and Saint-Lucia on the other hand show as well-contrasted morphs, here interpreted as representing two allopatric sibling species.

DISCUSSION

On the ground of the phenotypic variability patterns observed within the populations of *G. cordorae* and of *G. colombiana*, the adjacent distribution of both species cannot be interpreted as resulting from a step by step settling leading to a continuous geographic cline, which is the most current situation within the non-planktotrophic groups such as cystiscids.

It seems more likely, in the present case, that the "*G. cordorae* group" has been subject to several periods of dispersion associated to geologic and hydroclimatic events along the perturbed history of the eastern antillean region (FAIRBRIDGE, 1966). According to this view, *G. cordorae* may represent a "southern stock" belonging to the Venezuelan area, and *G. colombiana* may represent an "eastern stock" coming from the old inner arc of the Limestone Caribbes.

The *G. cordorae* group has apparently not any other representant in the Caribbean Province, but a close relative is represented in the Panamic Province as *G. phrygia* (Sowerby, 1846), which presents a very constant pattern from Western Mexico to Galapagos Islands.

ACKNOWLEDGEMENTS

I am indebted to Regis Delannoye (Trinité, Martinique), to Pierre Clovel (Fort-de-France, Martinique) and to Jacques Colomb (Marseilles, France) for their active contribution to this study, for their sampling efforts and precious observations as well as for the gift or the loan of material. Gérard Paulmier (Monteaux, France) also loaned useful material.

A special thanks is due to Tiziano Cossignani (Ancona, Italy) who performed the photos and the digital plates, and to Rafael La Perna (Catania, Italy) for the helpful correction of the text.

BIBLIOGRAPHY

BOYER, F., NEEFS, J. AND WAKEFIELD, A., 1998. A new species of *Persicula* from the Venezuelan region (Gastropoda: Cystiscidae). *Journal of Conchology*, 36 (4): 15-20.

COOVERT, G. A. AND COOVERT, H. K., 1995. Revision of the Supraspecific Classification of Marginelliform Gastropods. *The Nautilus*, 109 (2-3): 43-110.

DE JONG, K. M. AND COOMANS, H. E., 1988. *Marine Gastropods from Curaçao, Aruba and Bonaire*. E. J. Brill, Leiden, 261 pp.

FAIRBRIDGE, R. W., 1966. *The Encyclopedia of Oceanography*. Reinhold Publishing Corp., New York, 779 pp.

SOWERBY, G. B., II, 1846. Monograph of the genus *Marginella*, in *Thesaurus Conchyliorum, or figures and descriptions of Recent Shells*, 1 (7): 239-406, pls. 68-78. Sowerby, London.

Contributions to West-Mediterranean Solenogastres (Mollusca) with three new species

Contribuciones al conocimiento de los Solenogastres (Mollusca) del Mediterráneo occidental, con tres nuevas especies

Luitfried v. SALVINI-PLAWEN*

Recibido el 1-X-2002. Aceptado el 13-III-2003

ABSTRACT

Six species of West-Mediterranean Solenogastres are treated, three of which are described as new to science: *Micromenia subrubra* n.sp. from off Malta, *Macellomenia adenota* n.sp. from off Ceuta, *Urgorria monoplicata* n.sp. from off the Costa Brava. Records of other species (*Nematomenia banyulensis, Tegulaherpia* sp. and *Eleutheromenia sierra*) contribute to our knowledge of respective geographical distribution. The re-finding of *E. sierra* also results in the definition of a new genus *Scheltemaia* n.g. for two South-Australian, former *Eleutheromenia* species.

RESUMEN

Se estudian seis especies de Solenogastres del Mediterráneo occidental, incluyendo tres nuevas especies: *Micromenia subrubra* n.sp. de Malta, *Macellomenia adenota* n.sp. de Ceuta, *Urgorria monoplicata* n.sp. de la Costa Brava. Se aportan informaciones sobre otras especies, *Nematomenia banyulensis, Tegulaherpia* sp. y *Eleutheromenia sierra*, que contribuyen a un mejor conocimiento de sus distribuciones. La redescripción de *E. sierra* justifica la definición de un nuevo género *Scheltemaia* n.g. para dos especies descritas del Estrecho de Bass, Australia meridional.

KEY WORDS: Mollusca, Solenogastres, geographical distribution, new species.
PALABRAS CLAVE: Mollusca, Solenogastres, distribución geográfica, nuevas especies.

INTRODUCTION

The Solenogastres are a small class of aplacophoran Mollusca, characterised by the mantle cover of cuticle and unicellularily formed, calcareous mantle bodies or sclerites (scales, spicules, a.o.) and by the laterally rounded body with the foot narrowed to a longitudinal pedal groove. With respect to the mantle cover, to characters of the alimentary tract (no true radula ribbon, midgut without separate digestive gland) and to the lack of particular excretory organs (no emunctoria), they appear to represent a very conservative off-shoot of Mollusca. Apart from the plesiomorphic, aplacophoran mantle and a few other features, they are by diphyly also clearly different from the Caudofoveata (cf. SALVINI-PLAWEN, 2003).

Solenogastres are generally small (average 3 mm - 3 cm; rarely longer, up

* Institut für Zoologie, Universität Wien, A-1090 Wien (Vienna/Austria), Althanstrasse 14

to 30 cm), and about 230 species are nominally known at present. Their purely marine habitats (mostly below 50 m depth), their organisation based mainly on internal systematic characters, together with the great effort and expense required to collect them have clearly prevented broader assessments and a greater familiarity with this group. Much material from more recent collections (expeditions and individual samplings) awaits elaboration and will no doubt contribute to a still fairly fragmentary knowledge. This is also valid for basic faunistics (biodiversity, biogeography, etc.). Due to such incompleteness, all information - even if fragmentary - is of interest. In regard to the revised classification (SALVINI-PLAWEN 1978), systematic problems remain; these also concern several descriptions that are fragmentary compared to the required standard and await supplementation or revision.

The present contribution compiles Solenogastres from different samplings of the western Mediterranean Sea. Apart from enlarging our information on organisational diversity and providing geographical insight, this study also improves our understanding of the biodiversity of Solenogastres even within a fairly well investigated biogeographical region (cf. SALVINI-PLAWEN 1986, 1990).

SYSTEMATICS

Ordo PHOLIDOSKEPIA Salvini-Plawen, 1978

Solenogastres with a single layer of adpressed and overlapping solid, scaly mantle sclerites, sometimes supplemented by other solid sclerites; cuticle thin, no epidermal papillae.

Family DONDERSIIDAE Simroth, 1893

The family is characterised by two different types of mantle scales, by a monoserial radula provided with paired, long denticles, by the foregut glandular organs as subepithelial follicles (so-called type A in SALVINI-PLAWEN, 1972, 1978), as well as by the lack of respiratory organs. It includes seven genera (cf. SALVINI-PLAWEN 1978).

Genus *Nematomenia* Simroth, 1893

Type species: *Dondersia flavens* Pruvot, 1890.
Dondersia Hubrecht, 1888, partim; *Myzomenia* Simroth, 1893; *Herpomenia* Heath, 1911.

Definition: Solenogastres-Dondersiidae with common atrio-buccal opening; radula rudimentary: either monoserial radula with two pairs of distally touching denticles (bifid-monostichous type), or radula sheath without radula, in part forming the unpaired outlet for the paired foregut glandular organs; midgut without serial constrictions; terminal sense organ present; secondary genital opening single, no copulatory stylets.

Nematomenia banyulensis (Pruvot, 1890)

Dondersia banyulensis Pruvot; *Myzomenia banyulensis* (Pruvot) in Simroth 1893;

Diagnosis: Body distinctly red, elongate and slender, up to 30 mm, middorsal scales forming a longitudianl crest; main type of scales short and wide, distally pointed, proximally in part notched; mid-foregut forming a protrusible cone, without radula, radula sheath forming the single outlet of paired glandular organs and, by elongation, opening at the tip of the cone, posterior foregut curving anteriorly to open precerebrally into frontal midgut; no papillated dorsal foregut gland; musculus longitudinalis distinctly separated. Spawning ducts fused throughout, axially with one pair of receptacula seminis.

Remarks: This well-known species (up to 30 mm in length) is recorded along the European coasts with wide gaps from off Dalmatia/Croatia to the Trondheimsfjord/Norway (PRUVOT 1891, NIERSTRASZ AND STORK 1940, SALVINI-PLAWEN 1997, HANDL AND SALVINI-PLAWEN 2001). There is a recent finding of several 3-5 mm long, red specimens by C. Mifsud (26.8.2002) from off Ras il-Wahx/NW-Malta (ca.35°57´N, 14°19´E) at 120-140 m, and another record (25.6.1994) of two small individuals comes from the campaign FAUNA IBERICA III (PB 923-0121), station 186 A, from off Cabo Cros in front of Punta na Foradada/NE-Mallorca (39° 47.64′-39° 49.66′ N, 2° 40.78′-2° 38.71′ E) at 59-61 m from a bottom also characterised by the presence of Hydrozoa-Sertulariidae. This latter record interbridges the known occurrence from the Gulf of Naples and the Côte Vermeille (Banyuls).

One of the Malta animals (3.6 mm) and the larger individual of the Mallorca specimens (preserved only 3.2 mm long, 0.5 mm high and 0.4 mm wide) were serially cross sectioned (semithin ribbons of 2 µm with glassknife); they show all typical characters of *N. banyulensis* (particularly curved foregut with cone, etc.). Although the Mallorca animal (deposited in the Mus. Nacional Cienc. Nat., Madrid, mol. no. 15.02/15) contained eggs of Ø 80-100 µm and sperm, the receptacula seminis were not yet differentiated. As PRUVOT (1891: 716) indicates that young individuals are pale reddish or orange, the distinct red colour of both the small Mallorca animals (maximum size of only 3.5 mm) is of interest.

Genus *Micromenia* Leloup, 1948

Rupertomenia Schwabl, 1955

Type species: *Micromenia simplex* Leloup, 1848.

Definition: Solenogastres-Dondersiidae with atrial sense organ (vestibulum) and mouth separate; monoserial radula with one pair of lateral, curved denticles touching each other distally (bifid-monostichous type); midgut without serial constrictions; terminal sense organ (s) present; secondary genital opening single, no copulatory stylets.

Micromenia subrubra spec. nov.

Holotype: NW-Malta, off Ras il-Wahx, 35°57´N, 14°19´E, yellow mud and sand at 140 m (Sept. 1996); spicules and section series (cs 2 µm) on slides: Naturhist. Mus. Wien (NHMW), Moll. IVN 1002446.

Paratype 1: NW-Malta, off Ras il-Pellegrin, about 35°55′N, 14°19′E, 120 m (April 1994); spicules and section series (cs 2 µm) on slides: Nat. Hist. Mus. London, Rg.no. 20020531.

Paratype 2: NW-Malta, off Delli, grey mud at 140 m (June 1999); whole animal, 5 mm long (Fig. 10), preserved in ethanol: Naturhist. Mus. Wien (NHMW), Moll. IVN 102447.

Derivatio nominis: Latin *subrubrus* = not very bright red, reddish.

Diagnosis: Body reddish, to 5 mm x 0.5 mm in size (stretched in life up to 7 mm), dorso-posterior body end generally elongated. Calcareous mantle sclerites of two types: slender shovel-like scales and slightly curved solid needles. Anteriorly concentrated subepithelial glands opening into dorsal pharyngeal pouch; paired ventral foregut glandular organs with single opening; midgut with short rostral caecum. With one pair of receptacula seminis and vesiculae seminales. Mantle cavity extending as a ventrally open gutter onto the elongated dorso-posterior body portion, ventrorostrally with pouch; 2-4 dorsoterminal sense organs (Figs 1-4, 10, 12).

Material and methods: Several specimens had been collected by Constantine Mifsud (Malta) in April,June/July 1994, June 1995, August, Sept. and Nov. 1996, June 1999 and May 2001 from muddy bottoms off Western Malta in the area off Ras il-Pellegrin (between the Gnejna and Fomm ir-Rih bays), about 35°55'N, 14°19'E, at 120-160 m (see MIFSUD, 1996), and off cape Ras il-Wahx, about 35°57´N, 14°19´E, at 140 m.

Ribbons of semithin serial sections (cs 2 µm) of several specimens have been made with glassknifes and stained with Richardson's solution.

External appearance: The slender animals are generally 2.5-5 mm in length (Fig. 10), but when stretched in life may even reach a length of up to 7 mm. They are fairly susceptible to mechanical effects and easily damaged through sampling treatment. The animals exhibit in life a distinct, not very intensive reddish colour throughout, ranging from pink to red (see Fig. 4 in MIFSUD 1996). The hind end in adults shows a beak-like extension of the dorso-posterior body (Fig. 10); in smaller (juvenile or sub-mature) individuals (up to 3 mm in length) the posterior body in life may be swollen and appear to be still devoid of the dorso-posterior body elongation. The mantle sclerites are generally adjoining and give the body surface a somewhat shiny appearance; the mid-dorsal scales may form a low crest.

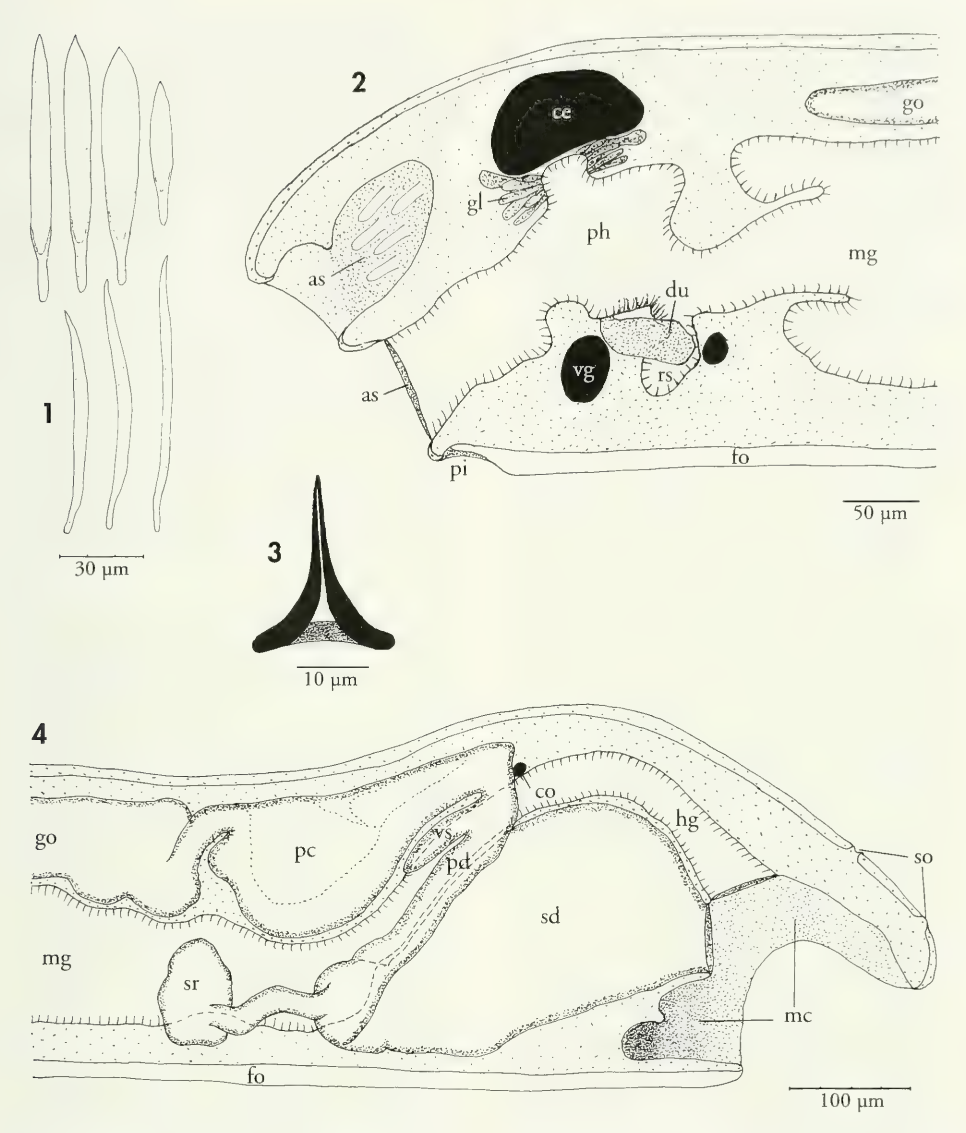
Mantle: Cuticle 7-15 µm. Calcareous mantle sclerites of two types (Fig. 1): a) very slender shovel- to trowel-like scales 55-110 µm long (handle 12-20 µm long) and 7-15 µm wide; b) slightly curved solid needles with indistinct handle, 80-110 µm long x 4-6 µm wide; both types may extend beyond the general body contour.

Foot and mantle cavity: Pedal ciliary pit flat and wide (125 µm), densely ciliated, without folds or ridges. Foot formed by posterior narrowing of the ciliated epithelium, changing along its course between a flattened ridge (25 µm wide) with centrally high cells and a real fold. It does not enter the mantle cavity.

Pedal gland voluminous with large follicles at both sides in the anterior body. Sole glands along pedal groove small, scattered, of same histological quality as pedal glands.

Mantle cavity as an elongated, ventrally open gutter extending along entire dorso-posterior beak-like body portion, densely ciliated without respiratory formations. At the beginning of this beak-like portion the ventroterminal body wall including "abdominal" spicules is curved dorso-anteriorly to form a wide dorsally open gutter facing the gutter of the mantle "cavity". This entire internal space is rostrally three-partitioned (Fig. 4): dorsal epithelium closing up as rectal opening (anus); central portion closing up to represent the short outlet of the voluminous spawning duct; the ventral portion becoming a rostral, wide and flattened pouch which - at least dorsally - appears to be lined by mantle epithelium (with cuticle-like substance and embedded small sclerites). More frontally this pouch either (holotype) continues ventrally in a fairly circular blind sack (Figs. 4, 12), or shows a mid-ventral ridge, implying distinct symmetry of the wide pouch; the latter condition (paratype 1) extends anteriorly until just below the end of the pericardium.

Musculature: Body wall musculature distinct but not very compact, its fibres showing a loose arrangement enclosing lacunae. No lateroventral reinforcement of longitudinal fibres. The regular dorsoventral bundles are weak and run peripherically, only occasionally causing



Figures 1-4. *Micromenia subrubra* spec.nov. 1: mantle sclerites; 2: organisation of the anterior body; 3: one radula tooth/plate; 4: organisation of the posterior body. Abbreviations, as: atrial sense organ; ce: cerebral ganglion; co: suprarectal commissure; du: outlet of ventral foregut glandular organs (type A); fo: pedal fold (foot); gl: follicles of glands; go: gonad; hg: hindgut (rectum); mc: mantle cavity; mg: midgut; mo: mouth opening; pc: pericardium; pd: pericardioduct; ph: pharynx; pi: pedal pit; rs: radula sheath; sd: spawning duct; so: terminal sense organ; sr: receptaculum seminis; vg: (first) ventral ganglion; vs: vesicula seminalis.

Figuras 1-4. Micromenia subrubra *spec.nov. 1: Escleritas del manto; 2: organización de la parte anterior del cuerpo; 3: diente radular; 4: organización de la parte posterior del cuerpo. Abreviaturas, as: órgano sensorial atrial; ce: ganglio cerebral; co: comisura suprarrectal; du: abertura de los órganos digestivos ventrales anteriores (tipo A); fo: pie; gl: grupos de glándulas; go: gónada; hg: recto; mc: cavidad del manto; mg: tubo digestivo; mo: abertura bucal; pc: pericardio; pd: pericardioducto; ph: faringe; pi: foseta pedal; rs: rádula; sd: conducto de la puesta; so: organo sensorial terminal; sr: receptáculo seminal; vg: (primer) ganglio ventral; vs: vesícula seminal.*

constrictions of the midgut. At the beginning of the pericardium, the inner/upper pair of dorsoventral bundles fuses with the peri-pericardial musculature.

Sensory system: Cerebral ganglion (110-125 µm wide, 75-80 µm high, 70 µm long) with separate connectives, the buccal ones first and very close to the ventral connectives. Four laterofrontal pairs of medullary roots of cerebral nerves (holotype), a ventro-lateral, a lateral and two subsequent dorsolateral ones; the lateral and dorsolateral roots connect at each side to an adjacent basal ganglion; this latter gives rise to only two (rather than three) nerves which lead together with the separate ventrolateral cerebral nerve to the atrial region. All these (six) nerves are medullary.

Lateral ganglia elongate (55 µm x Ø 30 µm) and adjacent to the cerebral ganglia. Ventral ganglia voluminous (Ø 60 x 45 µm), interconnected by two commissures, followed by another pair of ventral ganglia with their commissure, all posterior to the ciliated pedal pit (Fig. 2). Buccal ganglia (Ø up to 45 x 25 µm) posterio-lateral of the radula sheath between the follicles of the foregut glandular organs, interconnected by an exceptionally long commissure dorsoterminally of the sheath (150 µm when relaxed in the here 300 µm wide body, 60 µm when contracted and curved).

Suprarectal commissure overlying rectum just below end of the pericardium (Fig. 4). The lateral cords continue medullarly into the dorsoposterior body extension and form two additional thick commissures.

Atrial sense organ clearly separated from mouth. A distinct pre-atrial, ciliated pit is formed which leads into the voluminous atrium. Atrial ciliary tract running at the periphery of the opening only, frontally continuous with the preatrial pit. No dorsal ciliation. Cavity itself with several stoutish papillae, most being elaborated as pairs.

There are two (holotype) to four (paratype 1) subsequent dorso-terminal sense organs at the posterior elongation of the body (Fig. 4).

Alimentary tract: Mouth opening wide, separate from the atrium, leading into a voluminous (or but longitudinally folded) foregut with a dorsal enlargement below the cerebral ganglion. This pouch receives frontally subepithelial follicles of glandular cells (Fig. 2) without forming a papilla. Behind pouch, foregut with some distinct circular musculature.

Radula (Fig. 3) consists of monoserial teeth or plates (20 µm wide), each with a curved denticle laterally (up to 20 µm long), both which are very close medially and touch distally. Ventral foregut glandular organs present as wide ducts or ampullae (Fig. 2) with large subepithelial follicles filling the space to the midgut; wide ducts fuse to open by a single outlet ventral of the anterior radula.

Foregut in radular region with dorsal and lateral coating of small subepithelial foregut glands adjacent to strengthened circular musculature. Postradular foregut opening axially without sphincter into the (surrounding) midgut. Frontal midgut caecum short. Midgut, depending on the individual, at a more or less distinct distance from the body wall. Regionally showing irregular bulges, but no true serial constrictions due to the dorsoventral musculature and not forming regular lateroventral pouches. Middorsal ciliary tract present. In two specimens small nematocysts were embedded in the midgut epithelium.

Circulatory system: Atrium of heart forming a spacious invagination of the pericardial roof, being free in its anteriormost portion only and interconnected with the ventricle by one distinct opening. Ventricle for half or two-thirds its entire extension as an invagination of anterior pericardium.

Body spaces (pseudocoel) between the organs in part filled by distinct mesenchyme as well as blood cells. The latter consisting of round cells (Ø 2-5 µm) with in part densely granulated contents and well visible nucleus, and of more irregular, vacuolised cells (Ø 3-7 µm).

Gonopericardial system: The two gonads distincly separated throughout, containing eggs of at most 40 µm in diameter. Terminal portion of the gonads in fully mature animals serves as a voluminous sperm bag, then being ventrally continuous with the two short and wide gonopericardioducts, which are ciliated throughout. Ducts open dorsally into the pericardium, ciliation continuing as a paired, wide lateral tract throughout pericardium and entering pericardioducts. Pericardioducts emerging terminolaterally, each elaborating in its subsequent curve towards anterior an elongate and wound, anteriorly directed vesicula seminis (Fig. 4). Ciliated pericardioducts open rostrally from laterodorsal into the respective spawning duct.

Both spawning ducts connected anteriorly by a curved duct (stalk) with a voluminous receptaculum seminis (Fig. 4). After a short length, both glandular spawning ducts open anterio-laterally into a voluminous continuation showing a rostro-median pouch between the openings and being provided with a distinctly lower, ciliated epithelium. This subsequently single spawning duct soon widens laterally and becomes dorsally as well as ventrally lined by a high glandular epithelium and provided with some musculature. It opens by means of a short and simply-lined, central outlet, surrounded by musculature, into the "mantle cavity" (see above).

Discussion: It should be mentioned that two sub-mature animals showed an atrial sense organ without papillae, and it cannot be evaluated whether this refers to the sub-mature status or reflects a teratological condition.

The characteristic radula classifies the present animals within the Dondersiidae in the closer relationship of *Dondersia* Hubrecht, 1888, itself (see SALVINI-PLAWEN, 1978) and of *Micromenia*. As already pointed out earlier (SALVINI-PLAWEN, 1972: 218), the genus *Micromenia* differs from *Dondersia* by the absence of serial midgut constrictions due to the peripherical course of the dorsoventral muscle bundles. Such a condition, however, could perhaps be correlated with body size and would then not represent a good generic character. Apart from this, note the closer similarities with respect to the shovel- to trowel-like scales in the present species and in *Dondersia festiva* Hubrecht, 1888, as well as in *Heathia porosa* Heath, 1911 (see SCHELTEMA, 1998a). There is also a remarkable multiplication of dorsoterminal sense organs in some *Dondersia* species: two in *D. festiva* and *D. indica* Stork, 1941, three in *D. annulata* Nierstrasz, 1902, and eleven in *D. californica* Heath, 1911.

With respect to the mentioned elaboration of the midgut, the species in question belongs to *Micromenia*. At present, two *Micromenia* species are known, i.e. *M. simplex* Leloup and *M. fodiens* (SCHWABL, 1955). Besides the known geographic occurrence off Spitzbergen, *M. simplex* differs from the specimens at hand by several dominant characters, e.g. the lack of the dorsoposterior body elongation, the differentiation of scattered pharyngeal glands, the paired opening of the ventral foregut glandular organs and the unpaired spawning duct (LELOUP, 1948; SALVINI-PLAWEN, 1972). *M. fodiens* is known from SW Sweden and from Norway in the area off Bergen (SALVINI-PLAWEN, 1988); new evidence comes from the Skagerrak (two localities, 70-80 m) and the Trondheimsfjord (several localities, 185-530 m) (pers. comm. C. Handl, Vienna). *M. fodiens* differs from the present animals by the whitish body colour and the lack of the dorsoposterior body elongation as well as of a pedal fold, the shape of the scales, the rudimentary atrial sense organ without papillae, and also by details of the gonopericardial system (SCHWABL 1955, SALVINI-PLAWEN 1972, 1988).

M. subrubra spec.nov. is thus well-separated and its finding enlarges the biodiversity of *Micromenia* by a Mediterranean species. With respect to the body colour, together with *Nematomenia banyulensis* (above) and the enigmatic *Nematomenia (?) corallophila* (KOWALEVSKY, 1881) recorded upon *Corallium rubrum* (L.) off La Calle/Algeria (cf. SALVINI-PLAWEN 1997), *M. subrubra* is the third "red Solenogastre" in the region.

Family MACELLOMENIIDAE Salvini-Plawen, 1978

The family is characterised by the nail-shaped type of mantle sclerites, by a monoserial radula of serrate plates, by the foregut glandular organs as subepithelial follicles (so-called type A in SALVINI-PLAWEN, 1972, 1978), as well as by the presence of respiratory organs; at present it includes one genus only (cf. SALVINI-PLAWEN, 1978).

Genus *Macellomenia* Simroth, 1893

Type species: *Paramenia palifera* Pruvot, 1890.
Paramenia Pruvot, 1890, partim [non Brauer and Bergenstam, 1889]

Definition: Solenogastres-Macellomeniidae with solid acicular sclerites with enlarged basal plate; paired ventral foregut glandular organs (type A) with distally single outleading duct; terminal sense organ present; secondary genital opening unpaired; no copulatory stylets.

Macellomenia adenota spec. nov.

Material: A single specimen 1.65 mm long and 0.75 mm across was collected in May 1986 from the Strait of Gibraltar, off Punta Almina (North of Ceuta: 35°54.1'N, 0°16.5'W; 25-40 m). After examination of the mantle cover, ribbons of semithin serial sections (somewhat oblique cs 2 µm) were made with a glassknife and stained with haematoxyline-eosine.
Holotype: Mus.Nat.Hist.Nat. (Malacologie), Paris; section series
Derivatio nominis: Greek *adén* = gland, Latin *-otus* = provided with; referring to the paired pre-pallial "abdominal gland" in addition to the foregut glands.

Diagnosis: Body less than 2 mm long; mantle sclerites with spine slightly curved and up to 125 µm long, not forming a crest; atrial sense organ (vestibulum) and mouth opening separate; radula plates curved with seven denticles, the median one most promenent; midgut with paired rostral caecum, without regular lateral constrictions; with paired "abdominal gland" and paired abdominal spicules, all opening into a pre-pallial mantle invagination (Figs 5, 6, 16).

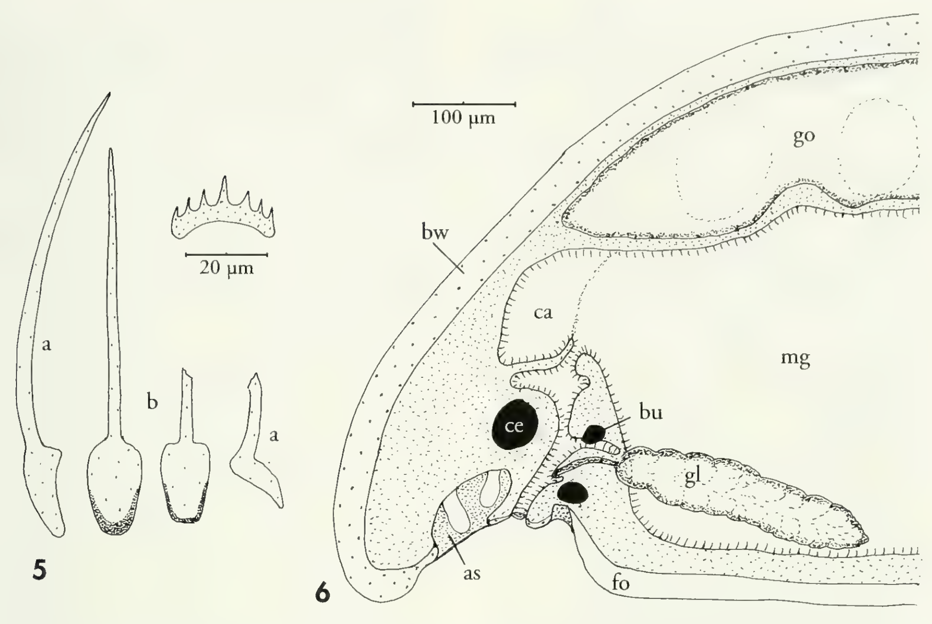
Description: Characteristic solid mantle sclerites (Figs. 5a, b) with a 70-100 µm long, slightly curved spine and an oblique basal plate (20-25 µm x 12-15 µm) reinforced at the free proximal rim. Some sclerites embedded in epidermis which includes several larger gland cells. Mantle cuticle thin, about 15 µm (13-20 µm).

Rear of body with mantle cavity not retained. With pre-pallial ventral mantle invagination with opening of a paired, slender pouch, each including a bundle of at least 12 slender spicules or spines (abdominal spicula). In addition, a paired short tube also opens aside the end of the foot lateral in the groove of the mantle invagination; it is elaborated just anterio-dorsal of each spicule pouch, provided with an epithelium of well elaborated glandular cells and surrounded by musculature ("abdominal gland", Fig. 16).

Pedal pit of foot simple, receiving the outlets of the pedal gland follicles. The single pedal fold soon flattens to a wide ciliated ridge ending with mantle invagination. Sole glands along groove present.

Body wall musculature without particular ventral reinforcement of the longitudinal layer. Serial dorsoventral bundles weak, running fairly close to body wall, not constricting midgut.

Preoral atrial sense organ ending as blind sack (Fig. 6), with few single,



Figures 5, 6. *Macellomenia adenota* spec.nov. 5: mantle sclerites from lateral (a) and frontal (b), and one radula plate; 6: organisation of the anterior body. Abbreviations, as: atrial sense organ; bu: buccal ganglion; bw: body wall (mantle and musculature); ca: midgut caecum; ce: cerebral ganglion; fo: pedal fold (foot); gl: ventral foregut glandular organ; go: gonad; mg: midgut.
Figuras 5, 6. Macellomenia adenota *spec.nov. 5: escleritas del manto en vista lateral (a) y frontal (b), y diente radular; 6: organización de la parte anterior del cuerpo. Abreviaturas, as: órganos sensorial atrial; bu: ganglio bucal; bw: pared del cuerpo (manto y musculatura); ca: ciego digestivo; ce: ganglio cerebral; fo: pie; gl: órgano glandular digestivo ventral; go: gónada; mg: tubo digestivo.*

stoutish papillae. Alimentary canal with mouth opening separate from atrium, leading into a short foregut. Animal with somewhat protruded radula apparatus, foregut forming a posterior pouch above radula sheath as well as a flat blind sack extending rostrally over the cerebral ganglion. Plates of monoserial radula only 25 µm wide and curved; with seven denticles, the median one distinctly being strongest (Fig. 5). No particular radula support.

Ventral foregut glandular organs, each consisting of a densely packed bunch of subepithelial follicles extending lateroventrally of the midgut and emptying at each side into short duct; both ducts uniting from lateral to a median outlet with circular musculature. Duct running below radula sheath and then below free radula to open beneath anteriormost plate of protruded radula.

Foregut opening into midgut above beginning radula, midgut giving rise from this area to a paired rostral caecum with high epithelium (30-120 µm) equal to that of midgut. Midgut with some nematocysts.

Nervous system with single cerebral ganglion (110 µm wide, 40 µm high, 35 µm long), connectives of body cords emerging separately. Buccal ganglia (Ø 25 µm) aside radula sheath (Fig. 6), their commissure over sheath. Ventral ganglia (Ø 65 x 35 µm) adjacent to pedal pit.

Animal mature, paired gonad with relatively large eggs (Ø up to 110 µm). Other organs of gonopericardial system (pericardium, spawning ducts, etc.) and mantle cavity not retained.

Discussion: Within Macellomeniidae, only two species of *Macellomenia* have been described so far, viz. *M. palifera* (Pruvot, 1890) and *M. aciculata* Scheltema, 1999, both provided with a similar, remarkable mantle cover of solid acicular spicules with enlarged basal plate. The present specimen fits well into that frame, but exhibits specific differences. *M. aciculata* possesses radula plates with five equal denticles, the mouth opens at the back of the atrial sense organ and there is a lack of abdominal spicules (SCHELTEMA 1999). The present specimen coincides with the geographically closer type species *M. palifera* by the radula plates with seven denticles and by the presence of invaginated pouches for abdominal spicules (PRUVOT, 1891: 790-791). There are specific differences however: (a) Curved radula plates with a distinctly prominent median denticle; (b) paired midgut caecum (not present in *M. palifera*; PRUVOT 1891: 790); (c) the paired "abdominal gland" (see below) emptying into the mantle invagination close in front of the abdominal spicules; (d) body length (though mature, less than 2 mm; *M. palifera* = 4-8 mm, Pruvot 1891: 727) and lack of a middorsal crest of spicules (PRUVOT, 1891: 727 and Fig. 4). Most probably (e), also in *M. palifera* the mouth opening is located within the preoral atrium.

Though the gonopericardial system, the mantle cavity and the terminal sense organ of the present specimen are not known, this animal clearly represents a proper species, *Macellomenia adenota* spec. nov.. An association of abdominal spicula with a paired gland has been reported also in *Squamatoherpia tricuspidata* (BÜCHINGER AND HANDL, 1996), though in different mutual arrangement. The histology of the present "abdominal glands" looks similar to that of spawning ducts; as no characters of the pericardium and mantle cavity are known, the glands could be the anlagen of those organs. If so, however, the spawning ducts would represent fairly unusual, lateral organs with medial opening into a pre-pallial mantle invagination. The presence or absence of a terminal sense organ, as well as the common (*M. aciculata*; *M. palifera*?) or separated atrial and buccal openings (*M. adenota*) are judged to be generic characters (SALVINI-PLAWEN, 1967b, 1978); due to the currently limited insight in species organisation and species diversity of Macellomeniidae, however, no reclassification is proposed herein.

No accurate evaluation is possible with regard to the *Macellomenia* specimens reported by Caudwell et al. (1995) from the Irish Sea at 80 m and 120 m. In view of the present species from the Strait of Gibraltar and of *M. aciculata* from 50° N, 13° W, the geographical distribution of each *Macellomenia* species appears to be limited. This is in contrast to an earlier estimation (Salvini-Plawen, 1997) and speaks against a conspecificity of the Irish specimens with the Mediterranean *M. palifera* from the Côte Vermeille. However, as already surmised (Salvini-Plawen 1997: 44), only an anatomical investigation of the Irish animals can clear up the conspecificity issue.

Family LEPIDOMENIIDAE Pruvot, 1902

The family is characterised by one type of scaly mantle sclerites, by a distichous radula, by the foregut glandular organs as subepithelial follicles (so-called type A in SALVINI-PLAWEN, 1972, 1978), as well as by the lack of respiratory organs; it includes at present three genera (cf. SALVINI-PLAWEN, 1978, 1988).

Genus *Tegulaherpia* Salvini-Plawen, 1983

Type species: *Tegulaherpia stimulosa* Salvini-Plawen, 1983.

Definition: Solenogastres-Lepidomeniidae with atrial sense organ (vestibulum) and mouth opening separate; terminal sense organ present; secondary genital opening unpaired; with copulatory stylets; no respiratory organs.

Tegulaherpia (?) spec.

Material: A single specimen was collected by Diego Moreno (Cabo de Gata/Almería) from sand below stones at Punta del Esparto nearby Los Escullos, Cabo de Gata (Southeast Spain, » 36°50'N, 02°03'W) at 1 m depth only. After examination of the mantle scales, ribbons of semithin serial sections (cs 2 µm) were made with a glassknife and stained by Richardson's solution. The slides (mantle scales and series section) are deposited in the Mus. Nacional Cienc. Nat., Madrid, mol. no. 15.02/14.

Description (Fig. 7): Specimen of 1.25 mm length and 0.35 mm across with an evenly rounded body (Fig. 7 A), not yet mature, though developing eggs visible. Of whitish colour and smooth surface with small, densely adjoining and strongly overlapping, delicate scales measuring 23 x 18 µm (Fig. 7 C) tightly adjacent. Atrial opening with anterior stereocilia ("bristles"), mouth and foot well visible in life (Fig. 7 A).

Unfortunately, the animal was very poorly preserved (partly in histolytic state) and only a few characters can be verified. Mouth opening distinctly separate from the atrial sense organ and leading into a fairly straight foregut surrounded by strong longitudinal musculature. Distichous radula consisting of paired, erect teeth with symphysis, each provided with a distal hook and four median denticles (Fig. 7 B). Foregut glandular organs not traceable. Single cerebral ganglion above the mouth (90 µm wide, 60 µm high, 45 µm long) gives rise to the connectives separately. Apart from the gut, no organ of the posterior body (spawning ducts, etc.) were clearly traceable. Gut containing several nematocysts, among them stenoteles, of a hydrozoan food.

Discussion: The mantle scales, the distinctly separate atrial sense organ and mouth, and the distichous radula fit well within the characters of the genus *Tegulaherpia*. Other characters, however, particularly the foregut glands and the copulatory stylets, could not be verified to confirm the generic classification. The shape and size of the scales (23 x 18 µm), and the radula (with four median denticles per tooth) do not coincide with the two known European *Tegulaherpia* species (cf. SALVINI-PLAWEN, 1988, 1997). No specific relationship can therefore be hypothesised. The Adriatic *T. stimulosa* Salvini-Plawen, 1983 possesses 30-40 µm x 20-25 µm sized scales and 4-5 radula denticles; the geographically overlapping, West-Mediterranean and NE-Atlantic *T. myodoryata* Salvini-Plawen, 1988 (= *T. celtica* Caudwell et al., 1995) shows somewhat larger scales, 30-45 µm x 20-30 µm, and 4-5 radula denticles (SALVINI-PLAWEN, 1988; HANDL AND SALVINI-PLAWEN, 2001). Fig. 7 D shows a scale of *T. myodoryata* from the most eastern record off Malta (see MIFSUD, 1996: Fig. 3) for comparison. Most specific differences between both known species, however, concern the arrangement of the copulatory stylet apparatus and the outlet of the (fused) spawning duct (SALVINI-PLAWEN, 1988); no comparison of the present animal can therefore be made. According to the mantle scales, the specimen appears to represent a species proper.

The habitat (sand) could also point to Meiomeniidae which have mesopsammic species; yet, these are characterised by mantle sclerites of two or three different kinds (SALVINI-PLAWEN, 1985; GARCIA-ÁLVAREZ, URGORRI AND CRISTOBO, 2000b).

Apart from the possible presence of an independent, third *Tegulaherpia* species, this finding is likewise of interest as the shallowest record of a solenogastre (one meter depth only). Due to the need of calmer waters for ciliary gliding, Solenogastres species are

generally very rare on substrata shallower than about 50 meters, including *Urgorria monoplicata* (below) or the mesopsammic representatives (cf. GARCÍA-ÁLVAREZ *ET AL.*, 2000b).. However, exceptions such as *Epimenia arabica* Salvini-Plawen and Benayahu, 1991, a large-sized species (13-21 cm) living hidden in Alcyonaria-colonies at 2-5 meters depth, occur.

Ordo CAVIBELONIA Salvini-Plawen, 1978

Solenogastres with acicular, generally hollow mantle spicules, cuticle mostly thick, with epidermal papillae.

Remarks: As some findings indicate (SALVINI-PLAWEN, 1978; SCHELTEMA AND KUZIRIAN, 1991; HANDL AND SALVINI-PLAWEN, 2002), the main character of this taxon - the hollow acicular spicules - strictly taken may be polyphyletic (not supported, however, by computerised cladograms; cf. SALVINI-PLAWEN, 2003). Investigations have also called attention on differences in the developmental arrangement of the spicules at the generic level, e.g. in Pararrhopaliidae (cf. Table I) or in Simrothiellidae: they are either (1) in a radial or (2) in a tangential alignment (HOFFMAN 1949). The latter may be produced (2a) in a single, obliquely disposed layer, or (2b) they are arranged in two or more fairly rectangularly intercrossing layers of low angle and almost embedded within the cuticle (and also termed "skeletal"; SCHELTEMA, 1999, SCHELTEMA AND SCHANDER, 2000). Another criterion exists with respect to the enclosed cavity: the spicules may be either thick-walled or thin-walled. Spicules may be distally hooked (or barbed), asymmetrically flattened and serrate, or asymmetrically axe-like enlarged (termed "captate" by ARNOVSKY, 2000).

Family PARARRHOPALIIDAE Salvini-Plawen, 1972

(Parameniidae Simroth, 1893; Paramenidae Pruvot, 1902; Perimeniidae Nierstrasz, 1909*); Pruvotiniidae Heath, 1911; Pruvotinidae Scheltema, 1998)

* As NIERSTRASZ (1909: 291-292) consciously introduced a synonymy (*Perimenia* instead of *Pruvotina*), his family "Perimeniidae" cannot be accepted as valid.

The family is characterised by a distichous radula, by the foregut glandular organs generally as subepithelial follicles (so-called type A in SALVINI-PLAWEN 1972, 1978), as well as by the additional presence of hooked mantle spicules and/or of a middorsal papillous pharyngeal gland and/or of respiratory organs (SALVINI-PLAWEN, 1978, GARCÍA-ÁLVAREZ, SALVINI-PLAWEN AND URGORRI, 2001); it includes 15 genera (Table I).

Genus *Eleutheromenia* Salvini-Plawen, 1967

(*Paramenia* Pruvot, 1890, partim [non Brauer and Bergenstamm, 1889]; *Pruvotina* Cockerell, 1903, partim; *Perimenia* Nierstrasz, 1909, partim)

Type species: *Paramenia sierra* Pruvot, 1890; Costa Brava.

Definition (amended): Solenogastres with hollow spicules in more than one layer, also including hooked ones; with common atrio-buccal opening; radula present, ventral foregut glandular organs subepithelial with paired outlet (type A); no dorsal papillous foregut gland; midgut with serial ventro-lateral constrictions; with dorsoterminal sense organ, with respiratory organs; unpaired secondary genital opening; no receptacula seminis and no copulatory stylets.

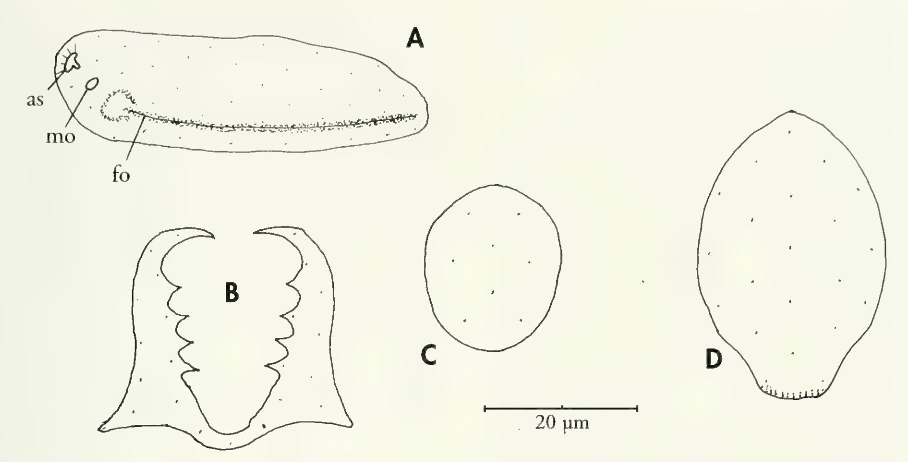


Figure 7. A-C: *Tegulaherpia (?)* sp. A: living animal from ventrolateral (sketch by Diego Moreno, Cabo de Gata); B: one pair of radula teeth with symphysis; C: one mantle scale. D: Mantle scale of *Tegulaherpia myodoryata* from off Malta. Abbreviations, as: atrial sense organ; mo: mouth opening; fo: pedal fold (foot).
Figure 7. A-C: Tegulaherpia *(?) sp. A: animal vivl en vista ventrolateral (esquema de Diego Moreno, Cabo de Gata); B: par de dientes radulares con sínfisis; C: escala del manto. D: Escala del manto de* Tegulaherpia myodoryata *de Malta. Abreviaturas, as: órgano sensorial atrial; mo: abertura bucal; fo: pie.*

Eleutheromenia sierra (Pruvot, 1890)

Paramenia sierra Pruvot, 1890

Material: One specimen (preserved 11,5 mm long, with lobes up to 1,7 mm high) of typical aspect and shape (Fig. 11) comes from the Skjörn Fjord north of Trondheim/Norway at 218 m depth (collected 2.3.1992 by G. Steiner, Vienna). Ribbons of semithin serial sections of this specimen (cs 2 µm) were made with glassknives and stained with toluidine-blue.
Type material no longer existent. The present material (series sections on slides) is deposited in the Naturhist. Mus. Wien (NHMW), Moll. IVN 102448.

Diagnosis: Body up to 12 mm x 2 mm with middorsal carina extended to a series of 15 prominent lobes; cuticle moderately thick, no epidermal papillae; spicules upright, tangential and intercrossed, as well as hooked, all hollow; elongate scales along the pedal groove. Abdominal spicules in a paired bundle, each consisting of numerous hollow straight elements. Radula teeth with distal hook, no median denticles; ventral foregut glandular follicles with paired duct, midgut with rostral caecum. Vesiculae seminales present, no receptacula seminis; up to 28 gill folds. Costa Brava, Bretagne, Irish Sea, Trondheim area; 40-128 m (Figs. 8, 11, 15).

Body wall: Body marked by a middorsal carina elaborated into three smaller and twelve subsequent prominent lobes (Fig. 11). In these bulges, circular musculature splits into a small subepithelial fraction (entering the bulge) and main fibres traversing the base of bulge, thus as usual delimiting body cavity. Space between this split musculature filled by mesenchyme and large vacuole (gland) cells. Regions between the lobes normally structured.

Epidermis covered by a 25-30 µm thick cuticle, locally reaching 50 µm. Especially in the posterior body, big, pluricellular epidermal glands, but no true epidermal papillae; only a few epi-

dermal protrusions scattered ventrally at both sides of the posterior pedal groove (mantle rims).

Mantle with three main types of hollow spicules (Fig. 8) in part extending beyond cuticle and thus resulting in a somewhat rough surface. Spicule types are (a) more or less straight ones (130-350 µm), (b) similar type with a harpoon-like indentation at the solid distal portion (up to 400 µm; see "species incerta II" in SALVINI-PLAWEN, 1978: 118-119 and *Unciherpia* in GARCÍA-ÁLVAREZ *ET AL.*, 2001), and (c) somewhat bent spicules (up to 125 µm) with solid distal portion forming a hook with knob at the turn. In addition, some very slender acicular spicules and, sporadically, ones with distal serration (d) occur; along the pedal groove (e) elongate scales (up to 80 x 13 µm).

Behind foot, a pair of ventromedially directed invaginations of the body epithelium, each embedded within ventral body wall musculature and housing a bundle of straight, 130 µm (or more) long, hollow abdominal spicules (Fig. 15). Epidermis as usual underlain by circular and longitudinal muscles; only weak lateroventral reinforcement of longitudinal musculature.

Foot and mantle cavity: The ciliated pedal pit gives rise to a single longitudinal fold which runs through the pedal groove. The foot ends, however, in front of the abdominal spicules, not entering the mantle cavity. The pedal gland is voluminous, and the sole glands open all over into the pedal fold and groove.

The mantle or pallial cavity holds at its posterior wall blunt gill folds (28 in PRUVOT, 1890, 1891). The hindgut opens frontally and, even more anteriorly, the outlet of the spawnings ducts opens ventrally. Between the end of the foot and the opening of the mantle cavity the invaginated bundles of the abdominal spicula are elaborated (Fig. 15). There are no copulatory stylets.

Sensory system: Cerebral ganglion unpaired (240 µm wide, central Ø 130 µm) giving rise to connectives separately; two pairs of small ganglia immediately adjacent to it, innervating the atrial region. Lateral body cords loosely provided, ventral ones more densely provided with nuclei; in the posterior body, cords are clearly medullary. In the ventral system, ganglia with commissures fairly densely elaborated, without correspondance to lateroventral connectives. The (first) ventral ganglia (Ø 80 µm) showing two commissures; without commissural sack. Buccal ganglia likewise prominent (Ø 60 µm).

Suprarectal commissure 150 µm long (Ø 40 µm) and interconnecting the ganglia posteriora superiora medullarly; at least two pairs of posterior nerves originate there.

Atrial sense organ with stoutish single or bifurcated papillae and bordered by a horseshoe-shaped ciliary fold, the dorso-posterior incurvings exclude the buccal groove continuous with the mouth.

Region of the dorsoterminal sense organ (close to the body end, according to PRUVOT, 1891) in present animal destroyed.

Alimentary tract: Mouth opening in the dorsoposterior area of the common atrio-buccal cavity, connected with the sensory region by a groove. Buccal space with high folds leading into the pharyngeal foregut; foregut with distinct pre-radular circular musculature and intercellularly opening, subepithelial pharyngeal glands; without compacted dorsal foregut gland (with papilla). Radula typically distichous, each tooth (25-30 µm high) with a distal hook; median denticles could not be discerned in the sections. Radula support represented by an assemblage of muscular and connective tissue. Ventral foregut glandular organs as follicles emptying at each side into distinct opening lateroventrally of radula (type A in SALVINI-PLAWEN, 1972, 1978). Midgut with rostral caecum and constricted only ventro-laterally by serial dorsoventral muscle bundles to form pouches. No nematocysts were observed within the gut. Middorsal ciliary tract widens to cover entire hindgut opening into mantle cavity above and behind unpaired spawning duct outlet.

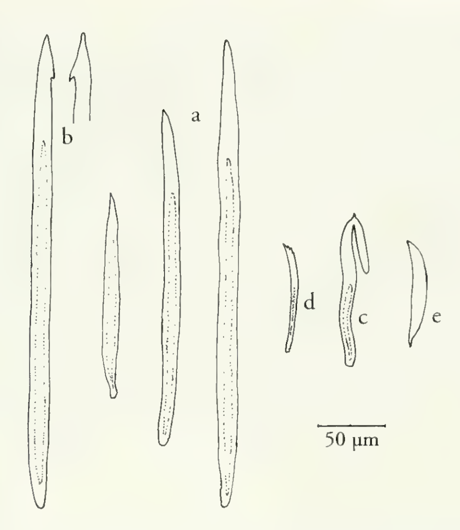


Figure 8. *Eleutheromenia sierra* (Pruvot) from the Trondheim area, types of mantle sclerites.
Figura 8. Eleutheromenia sierra *(Pruvot) del área de Trondheim, tipos de escleritas del manto.*

Gonopericardial system: Paired gonad showing developing germ cells in the posterior region within lateral sacks, the most posterior pair representing vesiculae seminales. Paired gonopericardial ducts opening dorsofrontally into pericardium with a paired anterior beginning. Pericardium voluminous with paired lateral ciliary tract and containing mature eggs (Ø 140 µm or 150 x 130 µm); probably due to such conditions, Pruvot (1891) cosistently termed the pericardium as "sac ovigère". Heart throughout as mediodorsal invagination, anteriorly very wide, then hanging by a double "mesenterium" into the pericardial lumen. Atrium clearly paired and fusing just before the axial transition into ventricle. Two kinds of blood cells: round, homogeneous ones (Ø 10 µm) and oval to round, vacuolated or variously granulated cells (10-20 µm long).

Pericardioducts emerging posteriorly, forming in their curve towards anterior short sacculations (vesiculae seminales) and opening laterodorsally into respective spawning duct. No receptacula seminis present. Spawning ducts voluminous, highly glandular, and subdivided into two equal sections: paired portion not axially continuous with unpaired section, the latter extending somewhat below the former, with paired dorsoventral interconnection. Unpaired section opening by means of simple outlet ventrally to exterior; this opening representing the anterior-most area of the mantle cavity opening.

Discussion: Though the present specimen comes from Skjörn Fjord (Trondheim region), the type locality of *Paramenia sierra* (Pruvot) is off the Costa Brava (Catalunia/Spain); for comparison with the description by Pruvot (1891), a full descriptive presentation of the new finding was given here. The specimen from Norway exhibits an almost identical organisation to *E. sierra* which includes, for example, also the dorsofrontal opening of the gonopericardioducts into the pericardium (Pruvot, 1891: Fig. 17). Some characters are not mentioned by Pruvot (such as, e.g. the posterior-most gonad serving as seminal vesicles, or the subdivision of the spawning ducts); there appear to be, however, just three discrepancies. First, the mantle spicules are not exactly identical. Second, in the region of the posterior body drawn as a cross section by Pruvot (1891: Fig. 61), Pruvot claims a "glande cloacale" (Fig. 61: y). Here, apart

from muscle fibres, numerous sole glands, the medullary ventral nerve cords as well as two connected ganglia innervating the spawning ducts are present in the Norwegian specimen. Some of these structures could represent Pruvot's gland as no real glandular organ is discernible; also the distance to the mantle cavity ("cloaca") is too long in both Pruvot's animal and the present specimen to represent a pallial gland.

A third and more essential point of disagreement of the new specimen with *Paramenia sierra* appears due to PRUVOT'S (1891: 790) somewhat misleading decription of the "petits caecums" at the end of the pedal groove, which he equalises with "l'appareil spiculaire pénial de *Proneomenia vagans*" [= *Pararrhopalia pruvoti* Simroth, 1893]. This equalisation led to the (incorrect) definition of *Paramenia sierra* as possessing copulatory stylets (THIELE, 1913b, SALVINI-PLAWEN, 1967b). As Pruvot, however, describes correctly in detail (PRUVOT, 1891: 790), *P. sierra* possesses "une paire de petits caecums" (plural!)... "plongés dans les muscles longitudineaux ventraux, dans chacun desquels" he recognised "un faisceau de spicules". This is an exact description of a paired bundle of abdominal spicules, such as exists in the present individual (Fig. 15).

The Norwegian specimen described here is thus regarded as conspecific with *Eleutheromenia sierra* (Pruvot).

Apart from the single, no longer existent type specimen (11-12 mm x 2 mm) of the original description by PRUVOT (1890, 1891) from off Portaló Island (Cap Creus/Costa Brava) at 75-80 m, and a finding from off Roscoff/Bretagne at about 40 m (Pruvot, 1897), several other records have been reported from the Irish Sea (cf. SALVINI-PLAWEN, 1997). Though without closer examination, due to their typical appearance (lobulated keel), however, these latter specimens may likewise belong to *E. sierra*; this is biogeographically supported by Pruvot's record from off Roscoff and by the present specimen (Trondheim area).

Paramenia sierra Pruvot was generically transferred by SALVINI-PLAWEN (1967b) to a new genus *Eleutheromenia*. A second species, *Pruvotina impexa* THIELE (1913a), after re-examination was generically separated later as *Labidoherpia impexa* (Salvini-Plawen, 1978). Most recently, SCHELTEMA (1998b) and SCHELTEMA AND SCHANDER (2000) described two *Eleutheromenia* species from the Bass Strait, South of Australia. According to the descriptions and a preliminary re-examination of specimens (*E. mimus* from Slope Station 40, *E. bassensis* from BSS-S 202; a full description of the anatomies is in preparation by Cl. Handl, Wien/Vienna, Austria), both these latter species differ markedly in several characters from *Eleutheromenia sierra* (PRUVOT, 1891 and above):

(1) They do possess copulatory stylets, in contrast to *E. sierra* (with abdominal spicules, see above);

(2) The ventral foregut glandular organs are tubular with epithelial gland cells (type C in SALVINI-PLAWEN 1972, 1978);

(3) In both species a "ventral commissure sack" of unknown function is present, similarily as in the gymnomeniids *Genitoconia*, *Wirenia [= Aesthoherpia]* and *Gymnomenia* (SALVINI-PLAWEN, 1967a, 1988, HASZPRUNAR, 1986, SCHELTEMA, 1999);

(4) The glandular anterio-ventral portion of the pericardium (not in open communication with the mantle cavity) - in connection with the pericardial glands - speculatively might represent part of some kind of excretory system.

With respect to the generic characters among the family Pararrhopaliidae (Table I), at least the above characters (1) and (2) concern the generic level. Apart from the different type of the foregut glandular organs in both Australian species (see also Unciherpiinae in GARCÍA-ÁLVAREZ *ET AL.*, 2001), copulatory stylets are only present in *Labidoherpia* Salvini-Plawen (with papillous dorsal pharyngeal gland) and in *Pararrhopalia* Simroth (with papillous gland, mouth separate). Thus, both these species, *E. mimus* and *E. bassensis,* do not fit into an existing genus and consequently are transferred to a separate genus *Scheltemaia* gen.nov. (see also the cladistic analysis in SALVINI-PLAWEN, 2003).

Table I. Generic characters in Pararrhopaliidae (see SALVINI-PLAWEN 1967b, 1978; GARCÍA-ÁLVAREZ *ET AL.*, 2001, GARCÍA-ÁLVAREZ AND URGORRI, 2001). A: ventral foregut glandular organs with subepithelial follicles (type A); C: ventral foregut glandular organs epithelial (type C); dts: dorso-terminal sense organ; pphf: peri-pharyngeal ring of follicular glands; -: absent; +: present.

Tabla I. Caracteres genéricos en Pararrhopaliidae (ver SALVINI-PLAWEN 1967b, 1978; GARCÍA-ÁLVAREZ ET AL., 2001, GARCÍA-ÁLVAREZ Y URGORRI, 2001). A: órganos glandulares digestivos ventrales con folículos subepiteliales (tipo A); C: órganos glandulares digestivos ventrales epiteliales (tipo C); dts: órgano sensorial dorso-terminal; pphf: anillo perifaríngeo de glándulas foliculares; -: ausente; +: presente.

	hooked spicules	dorsal gland	ventral glands	respiratory folds	mouth separate	copulatory stylets	radula	cuticle	dts
Pruvotina	+	+	A	+	-	-	+	thick	+
Pararrhopalia	+	+	A	-	+	+	+	thick	+
Labidoherpia	+	+	A	+	-	+	+	thick	+
Eleutheromenia	+	-	A	+	-	-	+	thick	+
Gephyroherpia	+	-	A	+	+	-	+	thick	+
Luitfriedia	+	-	A	+	-	-	-	thick	+
Lophomenia	-	+	A	?	+	-	+	thick	+
Metameria	-	+	A	-	+	-	+	thick	+
Hypomenia	-	+	A	-	+	-	+	thick	?
Halomenia	-	-	A	+	+	-	+	thick	+
Forcepimenia	-	-	A	?	+	?	+	thin	-
Scheltemaia	+	-	C	+	-	+	+	thick	+
Unciherpia	+	-	pphf	+	-	-	-	thin	+
Uncimenia	- (?)	-	pphf	+	+	-	-	thin	+
Sialoherpia	-	-	pphf	?	+	?	-	thick	+

Scheltemaia gen. nov.

Type species (with respect to the more accurate description): *Eleutheromenia mimus* Scheltema and Schander, 2000; Bass Strait (South Australia).

Definition: Solenogastres-Pararrhopaliidae with hollow spicules including hooked ones; with common atriobuccal opening; radula distichous; paired ventral foregut glandular organs each as tubes or sacks with epithelial gland cells (type C in SALVINI-PLAWEN 1972, 1978); no dorsal papillous foregut gland; with "commissure sack" between (first) ventral ganglia; with dorsoterminal sense organ, with respiratory organs; unpaired secondary genital opening; with copulatory stylets; no receptacula seminis. Two species known.

Family RHOPALOMENIIDAE Salvini-Plawen, 1978

The family is characterised by a thick cuticle and hollow acicular spicules in several layers, without hooked spicules; radula distichous or lacking; no papillate dorsal foregut gland, ventral foregut glandular organs subepithelial (type A) and/or epithelial (type C; SALVINI-PLAWEN, 1972, 1978); no respiratory organs. It includes five genera (GARCÍA-ÁLVAREZ AND SALVINI-PLAWEN, 2001).

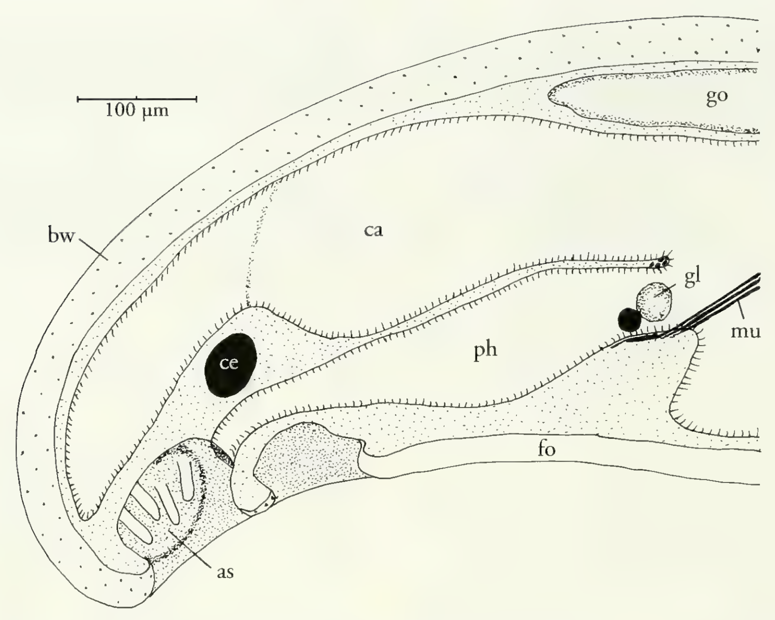


Figure 9. *Urgorria monoplicata* spec. nov. Organisation of the anterior body. Abbreviations, as: atrial sense organ; bw: body wall (mantle and musculature); ca: midgut caecum; ce: cerebral ganglion; fo: pedal fold (foot); gl: ventral foregut glandular organ; go: gonad; mu: muscle bundle; ph: pharynx.

Figura 9. Urgorria monoplicata *spec. nov. Organización del cuerpo anterior. Abreviaturas, as: órgano sensorial atrial, bw: pared del cuerpo (manto y musculatura); ca: ciego digestivo; ce: ganglio cerebral; fo: pie; gl: órgano glandular digestivo ventral; go: gónada; mu: unión muscular; ph: faringe.*

Genus *Urgorria* García-Álvarez and Salvini-Plawen, 2001

Type species: *Urgorria compostelana* García-Álvarez and Salvini-Plawen, 2001; off northwestern Spain.

Definition: Solenogastres-Rhopalomeniidae with epidermal papillae and hollow acicular spicules in several intercrossing layers; mouth opening within the atrium; without radula; paired foregut glandular organs epithelial (type C in SALVINI-PLAWEN 1972, 1978); dorso-terminal sense organ present; secondary genital opening unpaired, no copulatory stylets.

Urgorria monoplicata spec. nov.

Material: A single specimen of 2.2 mm length (Ø 0.5 mm) with evenly rounded body end originates from off the Costa Brava (Girona/Spain), from the "Furrió de Tamariu", sandy bottom in 35 m depth (collected 16.9.1990 by Luis Dantart, Barcelona).

After examination of the sclerites, ribbons of semithin serial sections (cs 2 µm) were made with a glassknife and stained with RICHARDSON's solution.

The specimen (series sections on slides) is deposited as holotype in the Mus. Nacional Cienc. Nat., Madrid, mol. no.15.02/13.

Derivatio nominis: Greek *monos* = one, Latin *plica* = fold; referring to the single pedal fold.

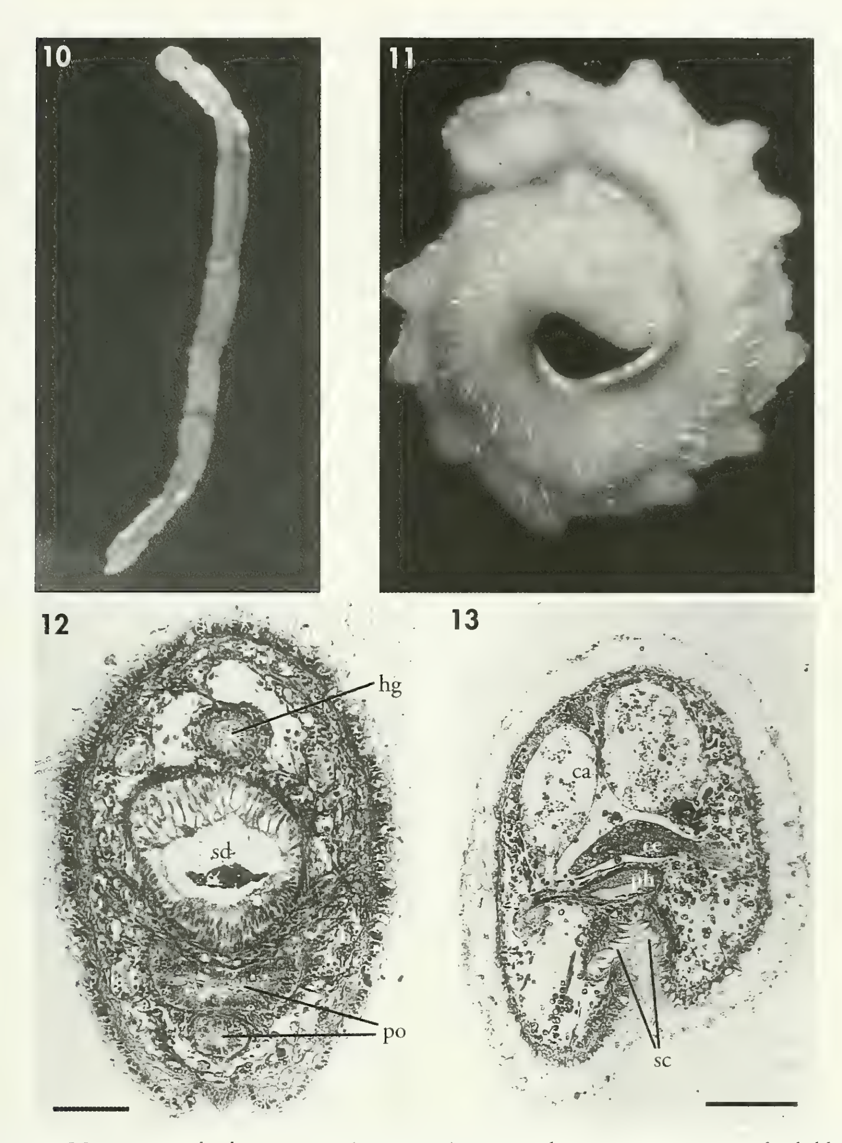


Figure 10. *Micromenia subrubra* spec.nov. (paratype 2), preserved 5 mm specimen; note beak-like extension of dorsal body end (below). Figure 11. *Eleutheromenia sierra* (Pruvot) from Trondheim area, preserved animal (11.5 mm long). Figure 12. *Micromenia subrubra* spec.nov., cross section through posterior body behind pericardium [hg: hindgut; po: anterior pouch of mantle cavity with separated anterio-ventral portion; sd: spawning duct] scale bar: 50 µm. Figure 13. *Urgorria monoplicata* spec.nov., cross section through mantle bridge (retracted) between atriobuccal opening and pedal pit with prepedal scales (sc) [ca: midgut caecum (paired); ce: cerebral ganglion; ph: pharynx] scale bar: 100 µm.

Figura 10. Micromenia subrubra *spec.nov. (paratipo 2), especimen fijado, 5 mm; nótese la extensión con forma de pico en la parte final (abajo). Figura 11.* Eleutheromenia sierra *(Pruvot) del área de Trondheim, animal fijado (11.5 mm). Figura 12.* Micromenia subrubra *spec.nov., sección del cuerpo posterior tras el pericardio [hg: intestino posterior, po: saco anterior de la cavidad del manto con porción separada antero-ventral, sd: conducto de puesta] escala: 50 µm. Figura 13.* Urgorria monoplicata *spec.nov., sección entre la abertura atriobucal y la foseta pedal con escalas pre-pedeales (sc) [ca: ciego digestivo, ce: ganglio cerebral, ph: faringe] escala: 100 µm.*

Diagnosis: Body 2.2 mm x 0.5 mm, with evenly rounded ends; cuticle fairly thin without keel formation; foot with one single fold only until mantle cavity; no radula or vestige of radula sheath, ventral foregut glandular organs as very small sacks opening ventrolaterally, terminal foregut with two pairs of strong muscle bundles to lateral body wall; midgut with large rostral caecum, rostrally paired, and with regular constrictions. Spawning ducts in their distal half fused, with simple opening; one pair of non-stalked, dorsoposterior receptacula seminis. Figs 9, 13, 14.

Mantle: Mantle producing a moderately thick cuticle only (40-50 µm) without marked thickenings; epidermal papillae distally balloon-shaped. Spicules (average 100 µm long) acicular and hollow, in tangential and intercrossing layers; no hooked or distally serrate spicules; along foot elongate scales (about 40 µm). Mantle bridge between atrio-buccal opening and pedal pit likewise with distinct scales (Fig. 13).

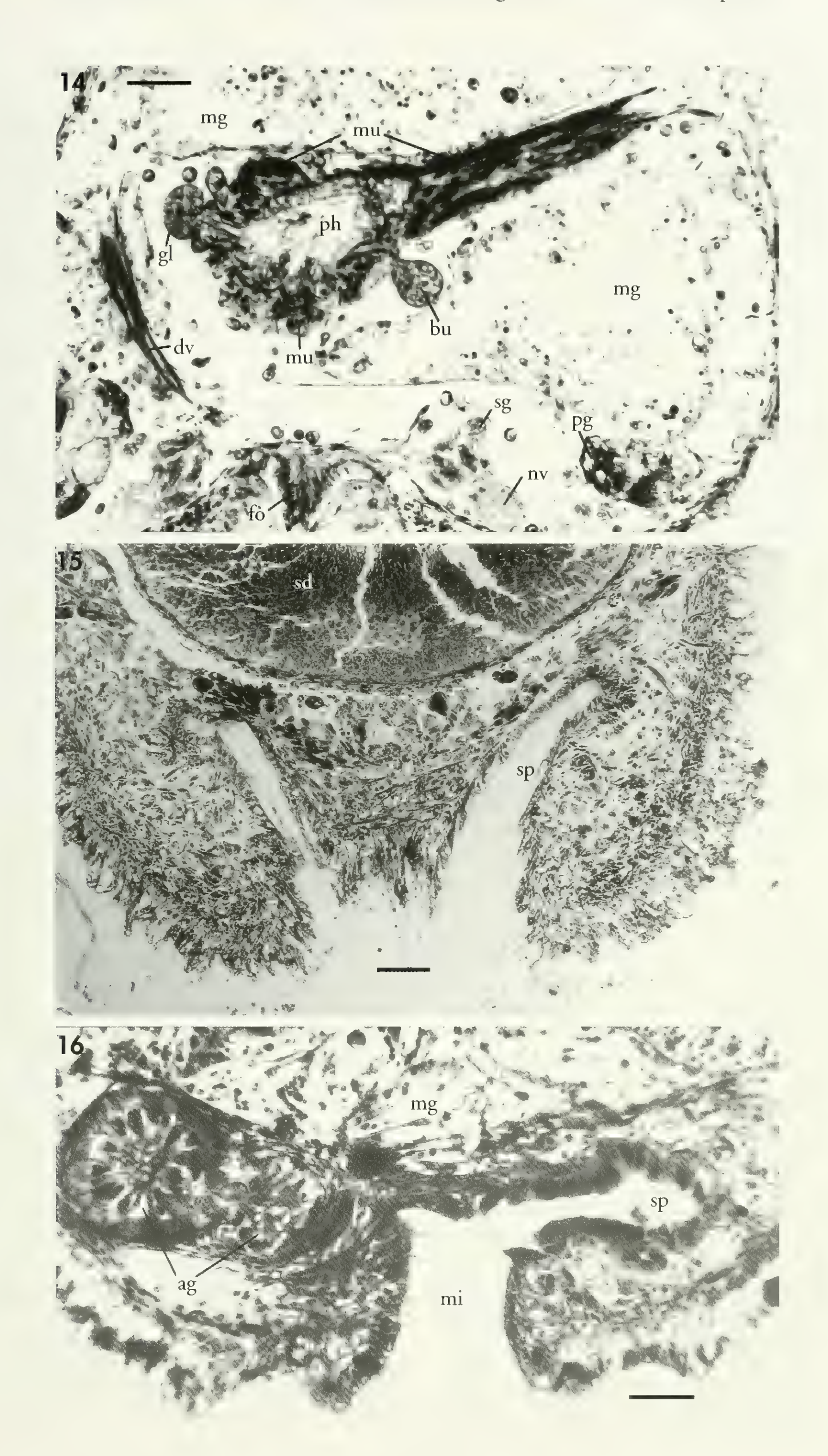
Foot and mantle cavity: Pedal pit receiving outlets of the voluminous pedal gland follicles that extend at both sides in the anterior body. Ciliated epithelium of pit not forming folds. At end of pit a single, distinct fold is differentiated, continuing until the pallial cavity. Sole glands parallel internally the foot. Mantle cavity representing a simple ciliated space receiving dorsomedially the rectum and medioventrally the single outlet of the posteriorly fused spawning ducts. There are neither respiratory organs nor accessory genital organs.

Musculature: Body wall musculature not very prominent, longitudinal portion showing an only moderately elaborated ventral reinforcement. Similarly, the dorsoventral bundles are typically differentiated, but not very strong. Their fairly medial course serially in distances of 50-80 µm causes deep constrictions of the midgut, forming respective lateral pouches. Special musculature is elaborated in connexion with the posterior foregut.

Sensory system: Fused cerebral ganglion above the mouth exhibiting a triangular outline in cross section (ventrally 125 µm wide, 60 µm high, 50 µm long). Laterofrontal pairs of small ganglionic formations innervate the atrial sense organ and the mouth opening. The connectives emerge laterally, the very short (20 µm) ventral and lateral ones in close contact. The (first) lateral ganglion at each side is latero-posteriorly elongated. The first "ventral" swelling, due to the short connective, is

(Right page) Figure 14. *Urgorria monoplicata* spec. nov., somewhat oblique cross section through region of terminal foregut [bu: right buccal ganglion; dv: dorsoventral muscle bundle; fo: pedal fold (foot); gl: left foregut gland; mg: midgut; mu: musculature forming bundles; nv: medullary ventral nerve cord; pg: (portion of) pedal gland; ph: pharynx; sg: sole gland], scale bar: 30 µm. Figure 15. *Eleutheromenia sierra* (Pruvot) from Trondheim area, cross section through pre-pallial (post-pedal) region with abdominal spicules (sp) [sd: spawning duct], scale bar: 50 µm. Figure 16. *Macellomena adenota* spec. nov., somewhat oblique cross section through pre-pallial (post-pedal) mantle invagination (mi) with "abdominal gland" (ag) just before opening, and with opening of pouch of abdominal spicules (sp) [mg: midgut], scale bar: 30 µm.

(Página derecha) Figura 14. Urgorria monoplicata *spec. nov. Sección oblicua a la altura de la región terminal del digestivo anterior [bu: ganglio bucal derecho; dv: musculatura dorsoventral; fo: pie; gl: glándula digestiva izquierda; mg: intestino medio; mu: unión muscular terminofaringeal; nv: cordón nervioso ventral; pg: (parte de) glándula pedal; ph: faringe; sg: glándula de la suela], escala: 30 µm. Figura 15.* Eleutheromenia sierra *(Pruvot) del área de Trondheim, sección de la región prepaleal (post-pedal) con espículas abdominales (sp) [sd: conducto de la puesta], escala: 50 µm. Figura 16.* Macellomena adenota *spec. nov., sección a la altura de la invaginación prepaleal (post-pedal) del manto (mi) con "glándula abdominal" (ag) justo antes de la abertura y con la abertura de la bolsa de espículas abdominales (sp) [mg: intestino medio], escala: 30 µm.*


14
mg
mu
ph
gl
mg
bu
dv
mu
sg
pg
nv
fo
15
sd
sp
16
mg
sp
ag
mi

located lateroventrally of the cerebral ganglion; the true ventral ganglia (Ø 60 µm x 30 µm) are formed above the beginning pedal fold. The remaining nervous system exhibits no unusual configuration. The 125 µm long suprarectal commissure is medullary (Ø 20 µm).

The atrial sense organ is bordered by the horseshoe-shaped ciliary tract, the dorsal limbs running parallel in distinct distance. The papillae are single and blunt (Ø 12-15 µm). A single dorsoterminal sense organ is elaborated middorsally above the posterior rectum.

Alimentary tract: Mouth opening dorsally at the rear end of the atrium, behind the curved ciliary tracts. Foregut representing an elongate tube, coated throughout its course by a delicate circular and a distinct longitudinal pharyngeal musculature. The epithelium consists in the anterior third of cubical cells (about 6 µm high), further on of irregularly club-shaped cells (8-12 µm high). It is intruded (partly in the anterior third, all along posterior third) and forms up to 12 distinct longitudinal folds.

A short distance in front of the ventral opening of the foregut into the midgut, the dorsal and lateral longitudinal pharyngeal muscles are concentrated to a pair of dorsolateral bundles which run transversely to the lateral body wall (Figs 9, 14). In that narrow area, the ventral pharyngeal muscles also become concentrated to a pair of ventral bundles; both extend (in the present specimen) asymmetrically at the same body side far posteriorly to join the musculature of the body wall (not before the middle of the body).

In this terminal portion of the foregut (formation of muscle bundles) the buccal ganglia (Ø 25 µm) are elaborated laterally (Fig. 14). The ventral glandular organs are separated by the buccal commissure ventral to the foregut; they open ventrolaterally into the foregut (Fig. 14). The organs are very small (40-50 µm long, Ø 30 µm), somewhat irregular sacks with glandular epithelium and a narrow outleading lumen (type C in SALVINI-PLAWEN 1972, 1978).

Midgut possessing a voluminous rostral caecum extending to body tip (Fig. 9), splitting frontally in the region of the mouth to a paired organ. Due to the serial muscle bundles, there are regular, deep lateral constrictions of the midgut. The midgut and its caecum include, among dissolved food material, also nettle capsules of Cnidaria.

Gonopericardial system: Paired, hermaphoditic gonad. Eggs at the connecting median walls measure maximally Ø 50 µm, indicating that full maturity has not been reached. The single heart auricle is an invagination of the pericardial roof, and the ventricle represents a largely free organ. There are two kinds of blood cells: a) small and coarsely structured granulocytes (Ø 5 µm); b) finely granulated, round haemocytes (Ø 10 µm).

The pericardioducts emerge lateroterminally. They open from dorsal into the respective spawning duct, the latter bending dorso-posteriorly into a scarcely separated, wide tube: receptaculum seminis. The spawning ducts are paired in their anterior portion; single opening into the central mantle cavity represents a simple, narrowed and short outlet (pore). There are neither vesiculae seminales nor accessory genital organs (copulatory stylets, abdominal spicula).

Discussion: Among the five genera of the family Rhopalomeniidae (GARCÍA-ÁLVAREZ AND SALVINI-PLAWEN, 2001), the present specimen coincides on the generic level with *Urgorria* based on the mantle elaboration, the atrio-buccal cavity, the lack of the radula and the configuration of the genital apparatus. The conformity with the hitherto sole species *U. compostelana* even includes such characters as the special scales at the mantle bridge between the atrio-buccal opening and the pedal pit, the similar musculature of the foregut, the unpaired to paired midgut caecum, and the receptacula seminis. Only few characters actually differ from those in *U. compostelana*: the body cuticle forms no middorsal reinforcement (in *U. com-*

postelana the 40-100 µm thick cuticle with spicules locally forms a middorsal crest up to 150 µm); only a single pedal fold is elaborated, which continues to the mantle cavity (in *U. compostelana* there are two pedal folds which fuse into a single one in the region of the anterior spawning ducts and flatten to a mere ridge close to the mantle cavity to a mere ridge); the position of the dorsoterminal sense organ differs (above the anterior mantle cavity; in *U. compostelana* at the rear of the body); the heart ventricle represents a free tube (in *U. compostelana* it remains an invagination throughout); the different relation of the foregut muculature (the muscle layer around the foregut in *U. compostelana* is weaker than the bundles at the terminal foregut, which are also much stronger than those in the present specimen 1). The present specimen thus represents a proper species *Urgorria monoplicata* spec.nov.

The common atrio-buccal opening in *Urgorria* separates this genus from all other Rhopalomeniidae, and *Urgorria* is thus well-defined (GARCÍA-ÁLVAREZ AND SALVINI-PLAWEN, 2001). At the same time, the condition of the ventral foregut glandular organs (type C in SALVINI-PLAWEN, 1972, 1978) required somewhat altering the definition of the family itself (see GARCICA-ÁLVAREZ AND SALVINI-PLAWEN, 2001 versus SALVINI-PLAWEN, 1978). The type species *Rhopalomenia aglaopheniae* (Kowalevsky and Marion, 1887) exhibits two pairs of ventral foregut glandular organs (cf. PRUVOT, 1891, NIERSTRASZ AND STORK, 1940, SALVINI-PLAWEN, 1972, GARCÍA-ÁLVAREZ *ET AL.*, 2000a): one pair forming subepithelial follicles around short ducts (type A) and one globular pair of epithelial glands (type C). All other *Rhopalomenia* species (representing *Entonomenia* Leloup to be restored cf. SALVINI-PLAWEN 1972) as well as all other Rhopalomeniidae except *Urgorria* (no information for *Pruvotia*) possess type A foregut glandular organs only; thus, *Urgorria* (uniquely type C organs) is well-contrasted also in this respect. Accordingly, we may accept that within Rhopalomeniidae the ventral foregut glandular organs became differently elaborated at the generic level as "subepithelial (type A) and/or epithelial (type C) " organs (see family characters above).

Apart from the presentation of a new species which establishes the occurrence of *Urgorria* also in the Western Mediterranean Sea, the finding of *U. monoplicata* at a fairly shallow depth of only 35 meters is worthy of note.

BIBLIOGRAPHY

ARNOVSKY, P., 2000. *Spiomenia spiculata*, gen. et sp. nov. (Aplacophora: Neomeniomorpha) collected from the deep waters of the West European Basin. *The Veliger*, 43: 110-117.

BÜCHINGER, Th. AND HANDL, Cl., 1996. *Squamatoherpia tricuspidata* gen.n. et sp.n. aus der Nordsee (Mollusca: Solenogastres: Dondersiidae). *Annalen des Naturhistorischen Museums in Wien*, 98B: 57-63.

CAUDWELL, C. M., JONES, A. M. AND KILLEEN, I J., 1995. Three Solenogastres from the Irish Sea, new to the British marine area. *Journal of Conchiology (London)*, 35: 257-269.

GARCÍA-ÁLVAREZ, O. AND SALVINI-PLAWEN, L.v., 2001. *Urgorria compostelana* gen.nov. et sp. nov. (Mollusca, Solenogastres, Rhopalomeniidae), a new species from off Galicia, Northwest of Spain. *Sarsia*, 86: 183-189.

GARCÍA-ÁLVAREZ, O., SALVINI-PLAWEN, L.V. AND URGORRI, V., 2001. *Unciherpia hirsuta* gen.nov., sp.nov. (Mollusca, Solenogastres: Pararrhopaliidae). A new species from Galicia, Northwest of Spain. *Journal of molluscan Studies*, 67: 113-119.

GARCÍA-ÁLVAREZ, O. AND URGORRI, V., 2001. *Luitfriedia minuta* gen.et sp.nov. (Mollusca: Solenogastres), a new species from Galicia, North-West Spain. *Cahiers de Biologie marine*, 42: 197-202.

GARCIA-ÁLVAREZ, O., URGORRI, V. AND CRISTOBO, F. J., 2000a. *Rhopalomenia aglaopheniae* (Kowelavsky y Marion, 1887) (Mollusca, Solenogastres, Rhopalomeniidae), presente en la costa norte de la Península Ibérica. *Iberus*, 18: 125-131.

García-Álvarez, O., Urgorri, V. and Cristobo, F. J., 2000b. Synopsis of the interstitial Solenogastres (Mollusca). *Argonauta*, 14: 27-37.

Handl, Cl. and Salvini-Plawen, L.v., 2001. New records of Solenogastres-Pholidoskepia (Mollusca) from Norwegian fjords and shelf waters including two new species. *Sarsia*, 86: 367-381.

Handl, Cl. and Salvini-Plawen, L.v., 2002. New records of Solenogastres-Cavibelonia (Mollusca) from Norwegian fjords and shelf waters including three new species. *Sarsia*, 87: 423-450.

Haszprunar, G., 1986. Feinmorphologische Untersuchungen an Sinnesstrukturen ursprüglicher Solenogastres (Mollusca). *Zoologischer Anzeiger*, 217: 345-362.

Hoffman, S., 1949. Über das Integument der Solenogastren, nebst Bemerkungen über die Verwandtschaft zwischen den Solenogastren und Placophoren. *Zoologiska Bidrag från Uppsala*, 27: 293-427.

Leloup, Eu., 1948. Un nouveau solénogastre à peau nue de l'océan glacial arctique, *Micromenia simplex* g.nov., sp.nov. *Bulletin du Musée royal d'Histoire naturelle Belgique*, 24 (19): 1-7.

Mifsud, C., 1996. Living Mollusca from circalittoral coastal muds, off western Malta. *La Conchiglia*, XXVIII/279, Suppl.: 23-41.

Nierstrasz, H., 1909. Die Amphineuren: I.Die Solenogastren. *Ergebnisse und Fortschritte der Zoologie*, 1: 239-306.

Nierstrasz, H. and Stork, H., 1940. Monographie der Solenogastren des Golfes von Neapel. *Zoologica (Stuttgart)*, (99): 1-99.

Pruvot, G., 1890. Sur queques Néoméniens nouvelles de la Méditerranée. *Archives de Zoologie expérimentale et génerale*, série 2, 8: XXI-XXIV.

Pruvot, G., 1891. L'organisation de quelques Néoméniens des côtes de France. *Archives de Zoologie expérimentale et génerale*, série 2, 9: 699-810.

Pruvot, G. 1897. Essai sur les fonds et la faune de la Manche occidentale (côtes de Bretagne) comparés à ceux du Golfe du Lion. *Archives de Zoologie expérimetale et génerale*, série 3, 5: 511-660.

Salvini-Plawen, L.v., 1967a. Neue scandinavische Aplacophora (Mollusca, Aculifera). *Sarsia*, 27: 1-63.

Salvini-Plawen, L.v., 1967b. Kritische Bemerkungen zum System der Solenogastres (Mollusca, Aculifera). *Zeitschrift für zoologische Systematik und Evolutionsforschung*, 5: 398-444.

Salvini-Plawen, L.v., 1972. Revision der monegassischen Solenogastres (Mollusca, Aculifera). *Zeitschrift für zoologische Systematik und Evolutionsforschung*, 10: 215-240.

Salvini-Plawen, L.v., 1978. Antarktische und subantarktische Solenogastres – Eine Monographie: 1898-1974. *Zoologica (Stuttgart)*, 44 (128): 1-315.

Salvini-Plawen, L.v., 1985. New interstitial Solenogastres (Mollusca). *Stygologia*, 1: 101-108.

Salvini-Plawen, L.v., 1986. Caudofoveata e Solenogastres del Mediterraneo. *Bolletino Malacologico (Milano)*, 22: 189-196.

Salvini-Plawen, L.v., 1988. Einige Solenogastres (Mollusca) der europäischen Meiofauna. *Annalen des Naturhistorischen Museums Wien*, 90 B: 375-385.

Salvini-Plawen, L.v., 1990. The status of the Caudofoveata and the Solenogastres in the Mediterranean Sea. *Lavori della Societá Italiana Malacologica*, 23: 5-30.

Salvini-Plawen, L.v., 1997. Fragmented knowledge of West-European and Iberian Caudofoveata and Solenogastres. *Iberus*, 15: 35-50.

Salvini-Plawen, L.v., 2003. On the phylogenetic significance of the aplacophoran Mollusca. *Iberus*, 21 (1): 67-97.

Salvini-Plawen, L.v. and Benayahu, Y., 1991. *Epimenia arabica* spec. nov., a solenogaster (Mollusca) feeding on the alcyonacean *Scleronephthya corymbosa* (Cnidaria) from shallow waters of the Red Sea. *PSZN I Marine Ecology*, 12: 139-152.

Scheltema, A. H., 1998a. Class Aplacophora. Taxonomic Atlas of the benthic fauna of the Santa Maria Basin and the Western Santa Barbara Channel. *Mollusca Part 1* (P.V.Scott and J.A.Blake, eds), 8 3-47. Santa Barbara Mus. Nat. Hist., California.

Scheltema, A. H., 1998b. Class Aplacophora. In Beesley, P. L., Ross, G. J. B. and Wells, A. (Eds.): Mollusca: The Southern Synthesis *Fauna of Australia*, 5/A: 145-159. CSIRO Publ., Melbourne.

Scheltema, A. H., 1999. New eastern Atlantic neomenioid aplacophoran molluscs (Neomeniomorpha, Aplacophora). *Ophelia*, 51: 1-28.

Scheltema, A. H. and Kuzirian, A. M., 1991. *Helicoradomenia juani* gen. et sp. nov., a Pacific hydrothermal vent Aplacophora (Mollusca: Meomeniomorpha). *The Veliger*, 34: 195-203.

Scheltema, A. H. and Schander, Ch., 2000: Discrimination and phylogeny of solenogaster species through the morphology of hard parts (Mol-lusca, Aplacophora, Neomeniomorpha). *Biological Bulletin*, 198: 121-151.

Schwabl, M., 1955. *Rupertomenia fodiens* n.g. n.sp., eine neue Lepidomeniide von der Südwestküste Schwedens. *Österreichische Zoologische Zeitschrift*, 6: 90-146.

Thiele, J., 1913a. Antarktische Solenogastres. *Deutsche Südpolar-Expedition*, 14, *Zoologie*, 6 (1): 35-65.

Thiele, J., 1913b. Mollusca. Solenogastres. *Das Tierreich*, 38: I-X and 1-57.

Poliquetos asociados a *Isognomun alatus* (Gmelin, 1791) (Bivalvia: Isognomonidae) en la costa nororiental de Venezuela.

Polychaete worms associated to *Isognomun alatus* (Gmelin, 1791) (Bivalvia: Isognomonidae) from northeastern coast of Venezuela

Óscar DÍAZ DÍAZ e Ildefonso LIÑERO-ARANA*

Recibido el 9-IX-2002. Aceptado el 9-IV-2003

RESUMEN

Treinta y ocho especies de poliquetos fueron encontradas asociadas a 175 ejemplares de la ostra boba *Isognomun alatus* (Gmelin, 1791) colectados en la costa nororiental de Venezuela. Las familias Serpulidae y Eunicidae fueron las mejores representadas con trece y siete especies, respectivamente. Entre las especies identificadas, *Caulleriella alata* Southern, 1914, *Eunice cariboea* Grube, 1856 y *Nematonereis hebes* Verrill, 1900, constituyen primeros registros para Venezuela.

ABSTRACT

Thirty-eight polychaete species were found on valves of 175 specimens of the oyster *Isognomun alatus* (Gmelin, 1791) collected in the northeastern coast of Venezuela. Serpulidae and Eunicidae were the families best represented with thirteen and seven species, respectively. *Caulleriella alata* Southern, 1914, *Eunice cariboea* Grube, 1856 and *Nematonereis hebes* Verrill, 1900, are new records for Venezuela.

PALABRAS CLAVE: Bivalvos, *Isognomun alatus*, Isognomonidae, Poliquetos, epifauna, Gran Caribe.
KEYS WORDS: Bivalves, *Isognomun alatus*, Isognomonidae, Polychaetes, Epifauna, Great Caribbean.

INTRODUCCIÓN

La ostra boba, *Isognomun alatus* (Gmelin, 1791), es un bivalvo común de las costas venezolanas (GÓMEZ, 1999). Este molusco está ampliamente distribuido en el Mar Caribe desde Florida hasta el sur de Brasil (ABBOTT, 1974; SIUNG, 1980; DÍAZ Y PUYANA, 1994) se desarrolla a poca profundidad y se encuentra asociado principalmente a substratos duros, especialmente a raíces de mangles, donde llega a formar densas colonias (ABBOTT, 1974). A pesar de ser muy abundante es la menos conocida entre las especies del género, entre los pocos estudios se citan los trabajos de TRUEMAN Y LOWE (1970) quienes estudiaron el efecto de la temperatura y exposición litoral sobre la fisiología cardíaca, y SIUNG (1980) sobre la biología de la especie.

Este bivalvo es desestimado comercialmente por la escasa cantidad de carne, sin embargo, en algunas comuni-

* Instituto Oceanográfico de Venezuela-Universidad de Oriente, Cerro Colorado, Edif. I.O.V. Piso 2, Lab. 208. Cumaná, Estado Sucre-Venezuela. e-mail: ecobentos12@hotmail.com, linero@hotmail.com

dades es consumido por sus pobladores y es ofrecido engañosamente a los turistas como ostras de mangle (*Crassostrea rhizophorae* Guilding, 1828). SIUNG (1980) señala que en Jamaica, el consumo de *I. alatus* se ha incrementado considerablemente debido a la reducción de las áreas de *C. rhizophorae*, ocasionada principalmente por la sobre-explotación de la misma y destrucción del manglar.

La superficie de las valvas de este molusco es lisa-escamosa, proporcionando un substrato adecuado para la fijación de organismos epibiontes que completarán allí su ciclo de vida; por otro lado, la disposición del molusco en grupos con numerosos individuos, muy próximos entre sí, brinda microhábitats disponibles a ser colonizados por otras especies, además de servir refugio contra los depredadores. En el Gran Caribe existen pocos estudios sobre la fauna asociada a moluscos bivalvos de interés comercial, excepto el de LIÑERO-ARANA (1999) sobre poliquetos asociados a de *Perna viridis* (Linné, 1758).

En el presente trabajo se analiza la comunidad de poliquetos asociados al bivalvo *I. alatus* colectados de las raíces de mangles en la costa nororiental de Venezuela.

MATERIAL Y MÉTODOS

El estudio se realizó entre enero y abril de 2002, los organismos fueron colectados en la Bahía de Mochima (64° 25´ 10" N, 11° 15´ 20" O), los mismos fueron retirados de las raíces del mangle *Rhizophora mangle* (Linné, 1753), y colocados en bolsas plásticas debidamente etiquetadas y éstas, a su vez, dentro de cavas con hielo y agua de mar para su traslado. Una vez en el laboratorio, se procedió a colocar los bivalvos en acuarios con aireación. Posteriormente, se procedió a separar los poliquetos de la superficie de las valvas y a fijarlos en una solución de formaldehído al 8% en agua de mar. Para la identificación de los mismos se emplearon las claves regionales: JONES (1962), BLAKE (1971), DAY (1973), SALAZAR-VALLEJO Y CARRERA-PARRA (1997), UEBELACKER, JONHSON Y VITTOR (1984), LIÑERO-ARANA, (1996), entre otras.

RESULTADOS Y DISCUSIÓN

Se analizaron 175 ejemplares del bivalvo *I. alatus* y 658 ejemplares de poliquetos identificándose 38 especies pertenecientes a 12 familias (Tabla I), entre éstas, las mejores representadas fueron Serpulidae con trece especies, lo que representa el 34,21% del total de especies identificadas, seguida por Eunicidae (18,42%) con siete y Terebellidae (10,53%) con cuatro. Mientras que, en cuanto a la abundancia por familia, Serpulidae presentó el mayor número de individuos (59,27%), seguida por Syllidae (10,49%) y Terebellidae (8,21%). Entre las especies más abundantes destacan *Pileolaria militaris* Claparède, 1868 (34,65%), *Salmacina* sp. (8,21%), *Exogone dispar* (Webster, 1879) (6,84%) y *Serpula* sp. (6,23%).

I. alatus habita principalmente en la zona submareal conformando densas agrupaciones, aunque es capaz de sobrevivir en la zona intermareal, en zonas de gran turbidez, en las que otros organismos filtradores no podrían habitar, SIUNG (1980) señala que puede soportar rangos de salinidad entre 10,9 - 40,0‰ demostrando una gran adaptabilidad a condiciones extremas e indica que la especie crece y se reproduce aun en presencia de especies incrustantes, sin embargo, no las menciona. Estas agregaciones de individuos proporcionan una mayor cantidad de microhábitats para la macrofauna bentónica, y específicamente a los poliquetos, así como protección contra los depredadores, alimento y áreas de reproducción. Por otro lado, la superficie escamosa del molusco permite la colonización de aquellas especies sedentarias, principalmente serpúlidos, que en algunos casos llegan a cubrir casi por completo la superficie de las valvas, y terebélidos.

Entre los poliquetos, varias especies de *Polydora* Bosc, 1802, han sido identificadas como plagas de cultivos de bivalvos, especialmente de pectínidos (CIOCCO, 1990; BASILIO, CAÑETE Y ROZBACZYLO, 1995; CÁCERES-MARTÍNEZ, 2001), afectando principalmente el crecimiento del bivalvo, debilitando la concha y haciéndolo más susceptible a infecciones o ruptura de las valvas. *P.*

Tabla I. Poliquetos asociados a la ostra boba *I. alatus* en la Bahía de Mochima. MI: móvil intersticial; Er: errante; E: epibionte; SI: sedentario intersticial.
Table I. Polychaete associated to I. alatus *in Bahía de Mochima. MI: mobile interstitial: Er: errant; E: epibiont; SI: sedentary interstitial.*

Especie	Localidad tipo	Material examinado	Microhábitat	Distribución
Spionidae				
Polydora websteri Hartman, 1943	Nueva Inglaterra	39	SI	Pacífico (Golfo de California, Hawai, Chile), Atlántico (Quebec, New Foundland hasta Florida, Golfo de México, Brasil, Argentina, Venezuela)
Cirratulidae				
Caulleriella alata Southern, 1914	Mar de Irlanda	16	SI	Cosmopolita
Phyllodocidae				
Phyllodoce (Anaitides) madeirensis Langerhans, 1880	Madeira	1	MI	Cosmopolita
Hesionidae				
Podarke obscura Verrill, 1873	Mar Caribe	11	MI	Gran Caribe
Hesione splendida Savigny, 1818	Mar Rojo	2	MI	Cosmopolita
Syllidae				
Syllis (*Typosyllis*) *lutea* Hartmann-Schröder, 1960	Mar Rojo	21	MI	Cosmopolita
Ehlersia cornuta Rathke, 1843	Noruega	3	MI	Cosmopolita
Exogone dispar (Webster, 1879)	Virginia	45	MI	Cosmopolita
Nereididae				
Nereis riisei Grube, 1857	Mar Caribe	6	MI	Gran Caribe
N. falsa Quatrefages, 1865	Mar Mediterráneo	3	MI	Cosmopolita
Amphinomidae				
Eurythöe complanata (Pallas, 1766)	Mar Caribe	14	Er	Circuntropical
Eunicidae				
Eunice vittata (delle Chiaje, 1828)	Nápoles	7	Er	Cosmopolita
Eunice cariboea Grube, 1856	Mar Caribe	10	Er	Costas americanas del Atlántico y del Pacífico
E. aphroditois (Pallas, 1788)	Océano ïndico	1	Er	Circuntropical
Lysidice ninetta Audouin y Milne-Edwards, 1833	Chancey, Isla (Francia)	7	Er	Cosmopolita
Lysidice collaris Grube, 1870	Mar Rojo	1	Er	Circuntropical
Marphysa sanguinea (Montagu, 1815)	Costas de Devon (Inglaterra)	4	Er	Cosmopolita
Nematonereis hebes Verrill, 1900	Mar Adriático	4	MI	Cosmopolita
Dorvilleidae				
Dorvillea cerasina Ehlers, 1901	Chile	4	Er	Costas americanas del Atlántico y del Pacífico
Terebellidae				
Terebella pterochaeta Schmarda, 1861	Cabo de la Buena Esperanza	24	SI-E	Cosmopolita
Terebella sp.	-	4	SI	-
Streblosoma hartmanae Kritzler, 197	Mar Caribe	22	SI-E	Gran Caribe
Polycirrus denticulatus Saint-Joseph, 1894	Francia	4	SI	Atlántico

Tabla I. Continuación.
Table I. Continuation.

Especie	Localidad tipo	Material examinado	Microhábitat	Distribución
Sabellidae				
Branchiomma nigromaculata (Baird, 1865)	Antillas	8	SI-E	Circuntropical
Hypsicomus phaeotaenia Schmarda, 1861	Mar Mediterráneo	7	SI-E	Circuntropical
Serpulidae				
Spirobranchus giganteus giganteus (Pallas, 1766)	Antillas	2	E	Gran Caribe
S. dendropoma (Schmarda, 1861)	Antillas	1	E	Gran Caribe
S. tetraceros (Schmarda, 1861)	Antillas	2	E	Cosmopolita
Hydroides dirampha Mörch, 1863	Antillas	32	E	Circuntropical
H. bispinosa Bush, 1910	Bermuda	4	E	Gran Caribe
H. elegans (Haswell, 1883	Port Jackson (Australia)	1	E	Cosmopolita
Hydroides sp.	-	1	E	-
Vermiliopsis annulata (Schmarda, 1861)	Jamaica	10	E	Costas americanas del Atlántico y del Pacífico
Pseudovermilia occidentalis (McIntosh, 1885)	Bermuda	12	E	Costas americanas del Atlántico y del Pacífico
Salmacina sp.	-	54	E	-
Serpula sp.	-	41	E	-
Protula submedia Augener, 1906	Mar Caribe (Sur)	2	E	Gran Caribe
Pileolaria militaris Claparède, 1868	Francia	228	E	Cosmopolita
Total de individuos		658		

websteri Hartman, 1943, único espiónido registrado en este estudio, representa menos del 6% del total de poliquetos colectados, siendo su abundancia y frecuencia relativamente baja, considerando que se analizaron 175 ejemplares del bivalvo. Los tubos mucosos del poliqueto están principalmente adheridos a los filamentos del biso, y no se observaron ampollas ni tubos mucosos sobre las valvas ni en el interior de ellas.

Al comparar los resultados obtenidos en este trabajo con otros similares, se observa que el número de especies registrado es superior a la mayoría. KEOUGH (1984) registró tres especies de espirórbidos como epibionte de *Pinna bicolor* Gmelin, 1791, señalando que el número de individuos era considerablemente bajo y que constituye menos del 2% de los epibiontes; LIÑERO-ARANA (1999) registró 11 asociadas a *P. viridis*; y DE LEÓN, LEIJA-TRISTÁN Y SALAZAR-VALLEJO (1993), registraron 28 especies asociadas a *Spondylus princeps unicolor* Sowerby, 1847, siendo Serpulidae la familia mejor representada, tanto en número de especies como en abundancia, con siete especies, mientras que en el presente estudio se registran 38 especies de las cuales 13 corresponden a serpúlidos, la dominancia de esta familia en ambos es debido a que las conchas de los bivalvos constituyen un substrato apropiado para su colonización y establecimiento de tubos de carbonato de calcio construidos por los miembros de esta familia. La presencia de sabélidos y terebélidos, especies que normalmente construyen sus galerías en el sedimento, sobre las valvas obedece a la acumulación de sedimento entre las escamas lo que permite la colonización de estos microhabitats.

La distribución geográfica indica un predominio de especies cosmopo-

litas (15) lo que representa más del 44%, seguido por aquellas especies cuya distribución está restringida al Gran Caribe (20,59 %), las circuntropicales (17,65%), las anfiamericanas, es decir que se encuentran tanto en las costas americanas del Pacífico y del Atlántico (11,76%), una sola especie (*P. websteri*) que se comporta como disyunta (anfiamericana-transpacífica), dado que ha sido registrada en Hawai, y una restringida al Atlántico, ambas con 2,94%. No se registraron especies endémicas.

Éste constituye el primer estudio sobre los poliquetos asociados de *I. alatus*.

AGRADECIMIENTOS

Los investigadores agradecen a FONACIT, por el financiamiento parcial de esta investigación a través del Proyecto S1-2000000946.

BIBLIOGRAFÍA

Abbott, R. T., 1974. *American seashells*. Van Nostrand Reinhold Ltd., New York, 2nd ed. 663 pp.

Basilio, C. D, Cañete, J. I. y Rozbaczylo, N., 1995. *Polydora* sp. (Spionidae) un poliqueto perforador de las valvas del ostión *Argopecten purpuratus* (Bivalvia: Pectinidae) en Bahía Tongoy, Chile. *Revista de Biología Marina de Valparaíso*. 30 (1): 71-77.

Blake, J. A., 1971. Revision of the genus *Polydora* from coast of North America (Polychaeta: Spionidae) *Smithsonian Contributions Zoology*, 75: 1-32.

Cáceres-Martínez, J., 2001. Parasitología en moluscos pectínidos. En Maeda-Martínez, A. N. (Ed.): *Los Moluscos Pectínidos de Iberoamérica: Ciencia y Acuicultura. Editorial Limusa, México*: 343-356.

Ciocco, N. F., 1990. Infestación de la viera Tehuelche (*Chlamys tehuelcha* (D´Orbogny)) por *Polydora websteri* Hartman (Polychaeta: Spionidae) en el Golfo de San José, (Chubut, Argentina): un enfoque cuantitativo. *Biología Pesquera*. 19: 9-18.

Day, J. H., 1973. New Polychaeta from Beaufort, with a key to all species recorded from North Carolina. *NOAA Technical Report NMFS Circ*. 375: 1-140.

De León Gonzalez, J. A., Leija-Tristán, A. y Salazar-Vallejo, S., 1993. Epifauna del ostión espinoso *Spondylus princeps unicolor* (Mollusca: Bivalvia) de Puerto Escondido, Golfo de California, México. *Revista de Biología Tropical*, 41 (3): 877-881.

Díaz , J. M. y Puyana. M., 1994. *Moluscos del Caribe Colombiano. Un catálogo ilustrado*. COLCIENCIAS, Fundación Natura e INVEMAR, Bogotá. 367 pp.

Gómez, A., 1999. *Los recursos marinos renovables del Estado Nueva Esparta, Venezuela*. Gómez-Gaspar Ed. Nva. Esparta Venezuela, 215 pp.

Jones, M. L., 1962. On some polychaetous annelids from Jamaica, the West Indies. *Bulletin American Museum Natural History*, 124 : 173-212.

Keough, M., 1984. Dynamics of the epifauna of the bivalve *Pinna bicolor*: interaction among recruitment, predation and competition. *Ecology*, 63 (3): 677-688.

Liñero-Arana, I., 1996. Aspectos bioecológicos de los poliquetos y descripción de algunas especies bénticas de la costa nororiental de Venezuela. *Trabajo de Ascenso a Profesor Titular*. Universidad de Oriente, Cumaná Venezuela, 254 pp.

Liñero-Arana, I., 1999. Poliquetos (Annelida: Polychaeta) asociados al mejillón verde *Perna viridis*, en la Península de Araya, Venezuela. *Boletín del Instituto Oceanográfico de Venezuela. Universidad de Oriente-Venezuela*, 38 (2): 53-62.

Salazar- Vallejo, S. y Carrera-Parra, L., 1997. *Taxonomía de Poliquetos*. CONACYT-ECOSUR: 64 pp.

Siung, A., 1980. Estudies on the biology of *Isognomun alatus* Gmelin (Bivalvia: Isognomonidae) with notes on its potencial as a commercial species. *Bulletin of Marine Science*, 30 (1): 90: 101.

Trueman, E. R. y Lowe, G. A., 1970. The effects of temperature and littoral exposure on the heart rate of a bivalve mollusk, *Isognomun alatus*, in tropical condition. *Composition Biochemical Physiology*, 38A: 555-564.

Uebelacker, J. M., Jonhson, P. G. y Vittor, B., 1984. *Taxonomic guide to the polychaetes of the northern Gulf of Mexico*. Final Report to the Mineral Management Service, contract 14-12-001-29091. J.M. Uebelacker, P.G. Jonhson y B. Vittor (Eds.) Barry A. Vittor y Associates, Inc., Mobile, Alabama. Vol. I-VII.

Yonge, C. M., 1968. Form and habit of species of *Mulleus* (incluiding the "Hammer Oysters") with comparative observations on *Isognomun isognomun*. *Biological Bulletin of Marine Biology Laboratory of Woods Hole*. 135: 378-405.

© Sociedad Española de Malacología ——————— Iberus, 21 (2): 67-90, 2003

The family Elachisinidae (Mollusca, Rissooidea) in the temperate and tropical Atlantic

La familia Elachisinidae (Mollusca, Rissooidea) en el Atlántico templado y tropical

Emilio ROLÁN* and Serge GOFAS**

Recibido el 29-I-2003. Aceptado el 18-IV-2003

RESUMEN

Se revisa el género *Elachisina* Dall, 1918 (Mollusca, Rissooidea) en el océano Atlántico, incluyendo aquellas especies que previamente habían sido situadas en otros géneros. En total, hay 4 especies ya conocidas (*E. floridana* (Rehder, 1943), del Caribe, *E. eritima* (Smith, 1891) de la Isla de Sta. Helena, *E. canarica* (Nordsieck y García-Talavera, 1979) (combinación nueva) de Canarias y *E. canaliculata* Rolán y Rubio, 2001, de las Islas de Cabo Verde), 7 que se describen como nuevas para la ciencia (*E. azoreana* n. sp., de las Azores, *E. tenuisculpta* n. sp., *E. pergrandis* n. sp., *E. pelorcei* n. sp., *E. senegalensis* n. sp., *E. gubbiolii* n. sp. y *E. catenata* n. sp., de la costa occidental africana) y una más que figuramos sin nombrarla por carecer de material suficiente. Las especies insulares son todas endemismos de sus respectivos arquipiélagos y tienen una protoconcha pauciespiral, lo que sugiere un desarrollo no-planctotrófico. Cuatro de las seis especies de la costa africana tienen protoconcha multiespiral y probablemente un desarrollo planctotrófico, pero solo tres de ellas se han encontrado en un área geográfica amplia, desde Mauritania o Senegal hasta Angola. Teniendo en cuenta las nuevas especies aquí descritas, la provincia Oeste-Africana se presenta como un centro de mayor riqueza específica conocido para la familia.

ABSTRACT

The Atlantic species of the genus *Elachisina* Dall, 1918 (Mollusca, Rissooidea), including those hitherto placed in other genera, are revised. In total there are four previously known species (*E. floridana* (Rehder, 1943), from the Caribbean, *E. eritima* (Smith, 1891), from St. Helena Island, *E. canarica* (Nordsieck and Garcia-Talavera, 1979) (comb. nov.), from the Canaries and *E. canaliculata* Rolán and Rubio, 2001, from the Cape Verde Islands), besides seven species which are described as new to science (*E. azoreana* n. sp., from the Azores, *E. tenuisculpta* n. sp., *E. pergrandis* n. sp., *E. pelorcei* n. sp., *E. senegalensis* n. sp., *E. gubbiolii* n. sp. and *E. catenata* n. sp. from the West African coasts) and one more species which we figure without naming it awaiting appropriate material. The insular species are endemic of their respective archipelagoes, and have a paucispiral protoconch that suggests non-planktotrophic development. Four out of the six West African species have a multispiral protoconch and a probable planktotrophic development, but among them only three have been collected in an extensive geographical range from Mauritania or Senegal to Angola. Taking into account the new species described herein and current knowledge, West Africa appears as a center of high species richness for the family.

KEY WORDS: Rissooidea, *Elachisina*, new species, Atlantic, West Africa.
PALABRAS CLAVE: Rissooidea, *Elachisina*, especies nuevas, Atlántico, África occidental.

* Investigador del Museo de Historia Natural, Campus Universitario Sur, 15782, Santiago de Compostela.
** Dept. de Biología Animal, Facultad de Ciencias, Universidad de Málaga, E-29071 Málaga.

INTRODUCTION

The genus *Elachisina* was introduced by DALL (1918), and the taxon received several different interpretations reviewed in PONDER (1985a). In this latter work, the anatomy of the soft parts and the taxonomy of the known species were detailed and the new family Elachisinidae was proposed. This author presented the species which he considered within this genus, from the Caribbean, western North and Central America, and the Indo-Pacific. No species were reported from the Eastern Atlantic mainland coast, but *Rissoa eritima* Smith, 1890 from St Helena, was included in *Elachisina*. Two more species have been described more recently and will be considered here: *E. canarica* (Nordsieck and García-Talavera, 1979) from the Canary Islands, and *E. canaliculata* Rolán and Rubio, 2001, from the Cape Verde Islands.

From the material collected in several expeditions to West Africa by both authors, as well as from sediments sent to us by amateur collectors and from museum material, we have found several additional species of this genus. The present work results from the study of this material. The type material collected by E.R. is deposited in Museo Nacional de Ciencias Naturales, Madrid, and paratypes in several collections; that collected by S.G. is in the Muséum National d'Histoire Naturelle, Paris.

The genus has a fossil record in the West European Tertiary, going back to the Eocene with *Elachisina minutissima* (Deshayes, 1861), *Elachisina loveni* (Bayan, 1873), (see Le Renard, on-line "fossils" database http://www.somali.asso.fr/fossils). Several other genera (*Entomope, Cirsope, Pseudocirsope, Lacunella, Dumasella*) are therein accepted as Elachisinidae. Representative species in the Neogene are *Elachisina moravica* (Rzehak, 1893) and *Pseudocirsope burdigalica* (Cossman and Peyrot, 1919) from the Miocene, but there are several other undescribed species (pers. comm. P. Lozouet, MNHN).

Abbreviations

AMNH American Museum of Natural History, New York
BMNH The Natural History Museum, London
MNCN Museo Nacional de Ciencias Naturales, Madrid
MNHN Muséum National d'Histoire Naturelle, Paris
CER private collection of Emilio Rolán
CFR private collection of Federico Rubio
CFG collection Franco Gubbioli
CJP private collection of Jacques Pelorce
CPR private collection of Peter Ryall
CWE private collection of Winfried Engl
spm specimen with soft parts
s empty shell
j juvenile
f fragment
sta. station (of a sampling cruise)
coll. in the collection of
leg. "legit", collected by

TAXONOMIC PART

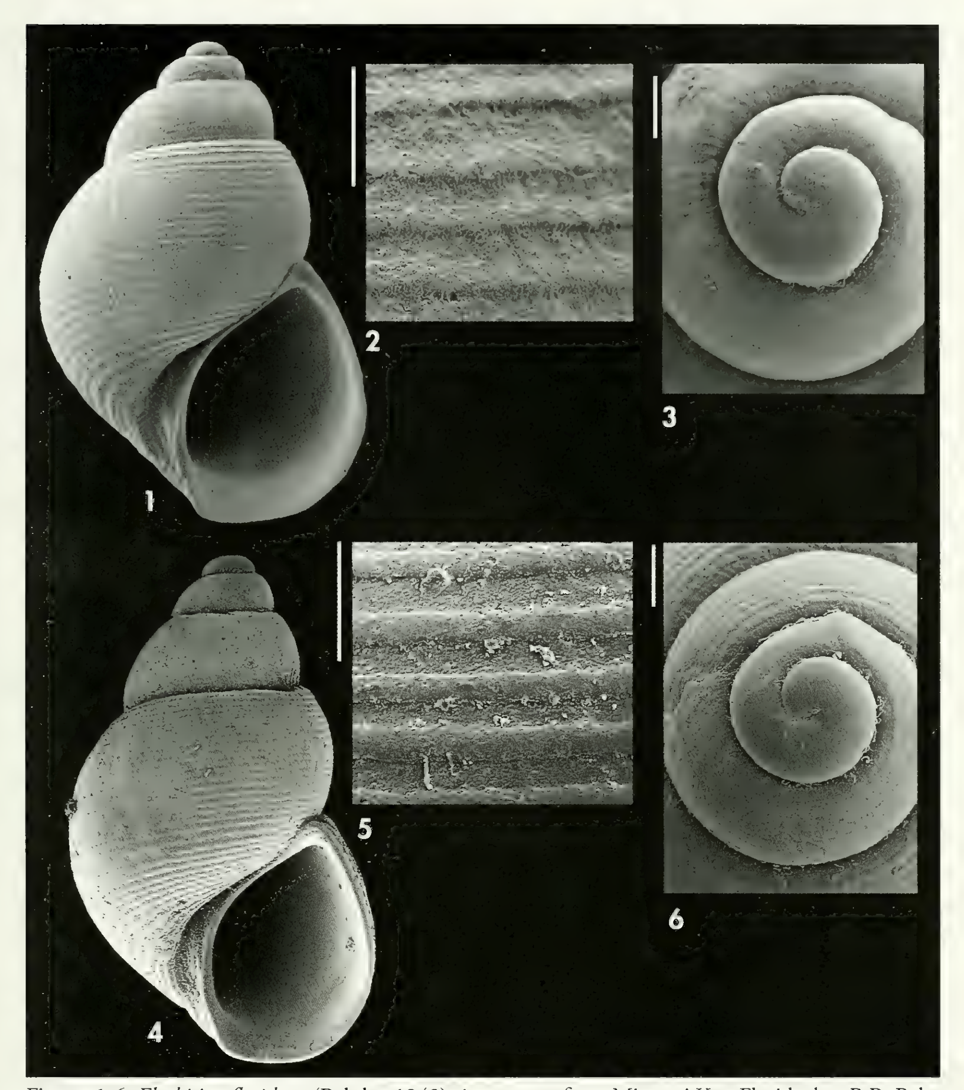
Family ELACHISINIDAE COMPLETA AUTOR Y AÑO

Genus *Elachisina* Dall, 1918

Type species: *Elachisina grippi* Dall, 1918; by original designation. Recent, western North America.

Elachisina floridana (Rehder, 1943) (Figs. 1-6)

Microdochus floridanus Rehder, 1943a p. 193-194, pl. 20, fig. 6 [Type locality: originally stated as Bonefish Key, Fla. corrected to Missouri Key in REHDER 1943b].



Figures 1-6. *Elachisina floridana* (Rehder, 1943). 1: paratype from Missouri Key, Florida, leg. B.R. Bales (MNHN; height 2.35 mm); 2: detail of the microsculpture of another paratype; 3: protoconch (same specimen as 2); 4: shell from Treasure Cove, Abaco, Bahamas, leg. C. Redfern (height 2.45 mm); 5: detail of the microsculpture (same shell as 4); 6: protoconch, same locality as 4, 5. Scale bars 100 µm.
Figuras 1-6. Elachisina floridana *(Rehder, 1943). 1: paratipo de Missouri Key, Florida, leg. B.R. Bales (altura 2.35 mm); 2: detalle de la microescultura de otro paratipo; 3: protoconcha (mismo ejemplar que 2); 4: concha de Treasure Cove, Abaco, Bahamas, leg. C. Redfern (altura 2.45 mm); 5: detalle de la microescultura (misma concha que 4); 6: protoconcha, misma localidad que 4, 5. Escalas 100 µm.*

Type material: Holotype in United States National Museum, not examined; paratypes in Los Angeles County Museum, Los Angeles; 8 spm, leg. B.R. Bales, in coll. Staadt, MNHN.
Other material examined: Bahamas: 9 s, Treasure Cove, Abaco, in beach drift, leg. C. Redfern 1981; 5 s, Treasure Cove, Abaco, in beach drift, leg. C. Redfern 1977; 2 spm collected alive, Treasure Cay, Bahamas, under stone in 1 m depth, leg. C. Redfern 1982.

Description: Shell (Figs. 1, 4) small, ovate-conical, solid, not transparent, with convex whorls separated by a deep, channelled suture. Protoconch (Figs. 3, 6) of a little more than one whorl with a diameter of 280-300 µm, depressed dome-shaped, and smooth. Teleoconch covered by numerous spiral grooves (Figs. 2, 5) which are about 8-10 very faint at the beginning and, in the last whorl, are about 30 up to the base and become stronger abapically. Spiral grooves about as wide as the interspaces, and rather smooth. Umbilicus narrow, bordered by a blunt keel and with small striae inside. Aperture piriform, with an angulation in the adapical part, and with the abapical edge slightly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Colour whitish. Dimensions up to 2.45 mm height.

Distribution: USA: Florida Keys, Louisiana; Mexico; Panama; Bermuda; Bahamas: Abaco and Grand Bahama Island; Brazil (see details in Malacolog database http://erato.acnatsci.org/wasp/search.php/2200)

Remarks: This taxon was described in a new genus *Microdochus* of the Rissoidae, and later recognized as a species of *Elachisina* by PONDER (1985a).

Elachisina eritima (E. A. Smith, 1890) (Figs. 7-10)

Rissoa eritima E. A. Smith, 1890. *Proc. Zool. Soc. London*,18: 289, fig. 40. [Type locality: St. Helena island].

Type material: 5 syntypes (Fig. 7) in BMNH.
Other material examined: St. Helena: 6 s, coll. Turton (MNHN); 1 j, off Jamestown 15° 54.5′ S, 5° 42′ W, leg. G. Kouyoumontzakis, Orstom (MNHN).

Description: Shell (Figs. 7, 8) small, ovate to ovate-conic, solid, opaque, with convex whorls. Protoconch (Fig. 10) of about one whorl and 1/8 more, light brown in colour, depressed dome-shaped, smooth, about 330 µm in diameter with a nucleus of 125 µm. Teleoconch covered by numerous fine spiral grooves (Fig. 9) which are about 11-13 at the beginning, 25 on the last spire whorl, and about 60 on the last whorl. Spiral grooves of similar size as interspaces, frequently with a thread in the interspaces. Umbilicus narrow, bordered by a sharp ridge and with fine commarginal striae inside. Aperture almost semicircular, with a blunt angulation in the adapical part, and with the abapical edge slightly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Colour whitish.

Dimensions: between 1.3 and 1.7 mm height.

Distribution: Only known from St. Helena. Supposedly endemic of this island.

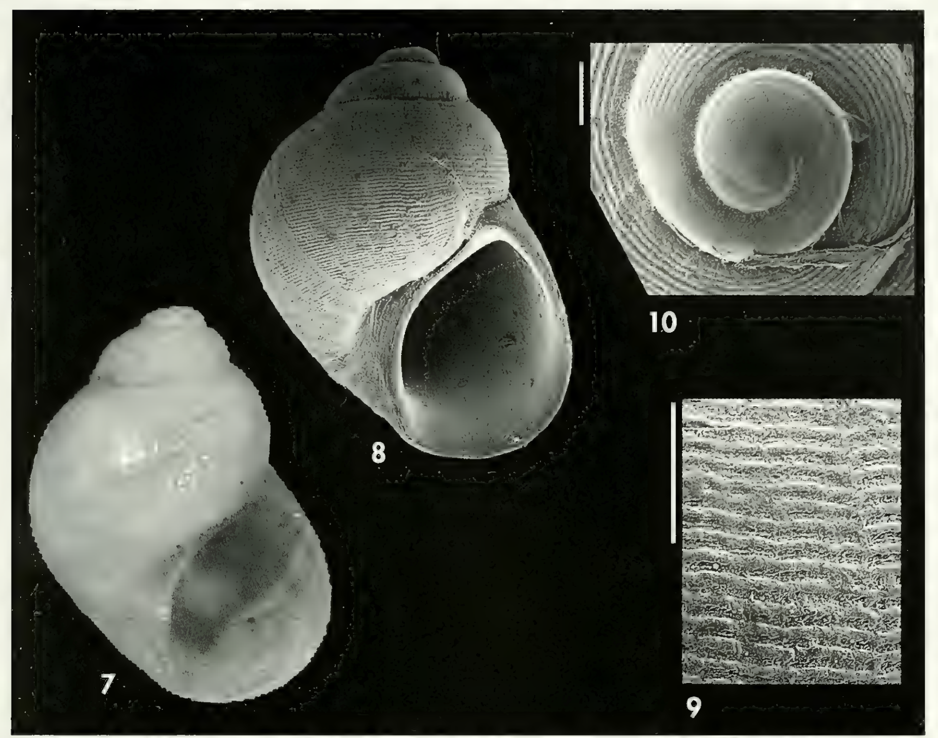
Remarks: *E. eritima* differs from other Atlantic species by its characteristically globose shape.

Elachisina canarica (Nordsieck and García-Talavera, 1979) (Figs. 11-17)

Cithna tenella canarica Nordsieck and García-Talavera, 1979. p. 289, pl. 11, fig. 1. [Type locality: Arrecife, Lanzarote I., Canary Is.].

Type material: In Museo de la Naturaleza y el Hombre, Santa Cruz de Tenerife, not examined.
Other material examined: Canary Islands: 3 spm, 3 s, La Restinga, El Hierro, 30 m (CWE).

Description: Shell (Figs. 11, 12) small, ovate to ovate-conic, solid, not transparent, with convex whorls. Protoconch (Fig. 15) of a little more than one whorl



Figures 7-10. *Elachisina eritima* (E.A. Smith, 1890). 7: syntype from St Helena (BMNH); 8: shell from St Helena, coll. Turton (MNHN; height 1.66 mm); 9: microsculpture of the same shell; 10: protoconch, same locality. Scale bars 100 µm.
Figuras 7-10. Elachisina eritima *(E.A. Smith, 1890). 7: sintipo de Santa Helena (BMNH); 8: concha de Santa Helena, coll. Turton (MNHN; altura 1.66 mm); 9: microescultura de la misma concha; 10: protoconcha, misma localidad. Escalas 100 µm.*

with a diameter of 360 µm, light brown, depressed dome-shaped, and smooth. Teleoconch covered by numerous spiral grooves (Fig. 14) which are about 12-13 at the beginning and, in the last whorl, are about 48-50 up to the base. Umbilicus narrow, bordered by a sharp keel and with small striae inside. Aperture ovate-piriform, with an angulation in the adapical part, and with the abapical edge slightly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Colour whitish.

Soft parts: The dry animal is apparently unpigmented with very evident and relatively large fecal pellets in its intestine. Operculum (Fig.13) paucispiral, thin and transparent. Radula (Figs. 15, 16) as in other species of the genus (see PONDER, 1985).

Distribution: Only known from the Canary Islands.

Remarks: This taxon was described as subspecies of *Cithna tenella* Jeffreys, 1869, but is unrelated with this species now classified in the Rissoidae as *Benthonella tenella* (see BOUCHET AND WARÉN, 1993: 697-701).

It most resembles *E. azoreana* spec. nov. but is more solid and slender (H/D ratio 1.5 instead of 1.4). The Caribbean species *E. floridana* is larger, more slender, with one more whorl, a more tumid profile of the spire and a narrower umbilicus.

Elachisina azoreana spec. nov. (Fig. 17-19)

Type material: Holotype (Fig. 17) and 11 paratypes from type locality (MNHN).
Type locality: Vila do Porto (depth 6-9 m), Santa Maria, Azores Archipelago.
Etymology: The specific name is after the archipelago where the species was found.

Description: Shell (Fig. 17) small, ovate to ovate-conic, solid, opaque, with convex whorls. Protoconch (Fig. 18) of one whorl and 1/8, transparent, dome-shaped, smooth, about 350 µm in diameter with a nucleus of 109 µm. Teleoconch covered by numerous spiral grooves which are about 11-13 at the beginning, 25 over the end of the spire and about 40 on the last whorl. Spiral grooves (Fig. 19) very shallow and narrow, with wider interspaces, and a small thread visible inside in some areas. Umbilicus narrow, with a faint rim situated well inside and terminating the spiral sculpture, then commarginal striae in its innermost part. Aperture piriform, with a blunt angulation in the adapical part, and with the abapical edge very slightly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Colour white.

Dimensions: Holotype 1.5 mm high and 1.1 mm in diameter.

Remarks: This species most resembles *E. canarica* but the latter is narrower, more solid, a little larger, and has a more distinct keel delimiting the umbilicus and protruding over the apertural edge. Also its microsculpture has microchannels in the interspaces between threads which are not seen in *E. azoreana*.

The general shell morphology, and particularly the conformation of the umbilical area, resemble very much *E. tenuisculpta* spec. nov. The main difference is in the paucispiral protoconch, but also the size is smaller and the spiral grooves are wider than in *E. tenuisculpta*.

Elachisina canaliculata Rolán and Rubio, 2001 (Figs. 21-25)

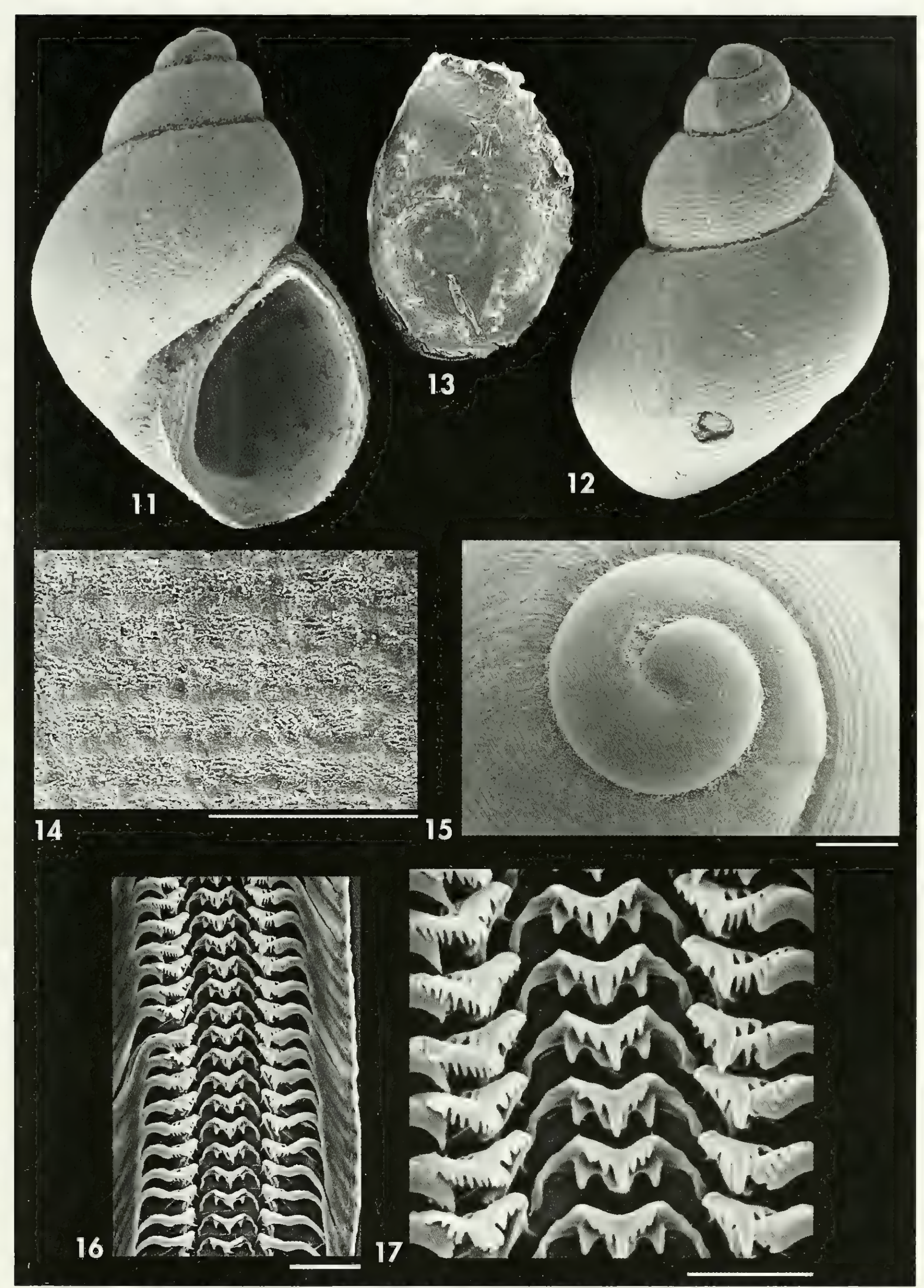
Elachisina canaliculata Rolán and Rubio, 2001. *Novapex*, 2(4): 133-136. [Type locality: Baia Teodora, North of Sal Rei, Boavista Island].

Type material: Holotype (Fig. 22) in MNCN (15.05/44327). Paratypes in MNHN (1), DBUA (1), CER (1), CFR (1).
Other material studied: Cape Verde Archipelago: Sal: 1 s, Mordeira, 5 m (destroyed during the study). Boavista: 2 s, Sal Rei, 10 m; Santiago: 1 s, Praia, 8 m.

Description: Shell (Figs. 21-23) small, ovoid, thin, somewhat transparent, with 2-3 whorls separated by a well defined suture. Protoconch (Figs. 23, 25) globose, smooth, with a little more than 1 whorl, and a maximum diameter difficult to be sized due to the gradual transition to the teleoconch (258 µm is mentioned in the original description). Nucleus of the protoconch 137 µm in diameter. Holotype with 3 slightly convex teleoconch whorls sculptured with spiral grooves (Fig. 24) which are almost canal-like, and cover the entire shell surface (numbering between 22-25 on the last whorl, with the final 3-4 grooves reaching into the umbilical funnel). Umbilicus is narrow, with a faint rim situated well inside and terminating the spiral sculpture. Aperture oval, with an angulation in the adapical part, and with the abapical edge distinctly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Central area of the columella curved and reflected towards the umbilicus.

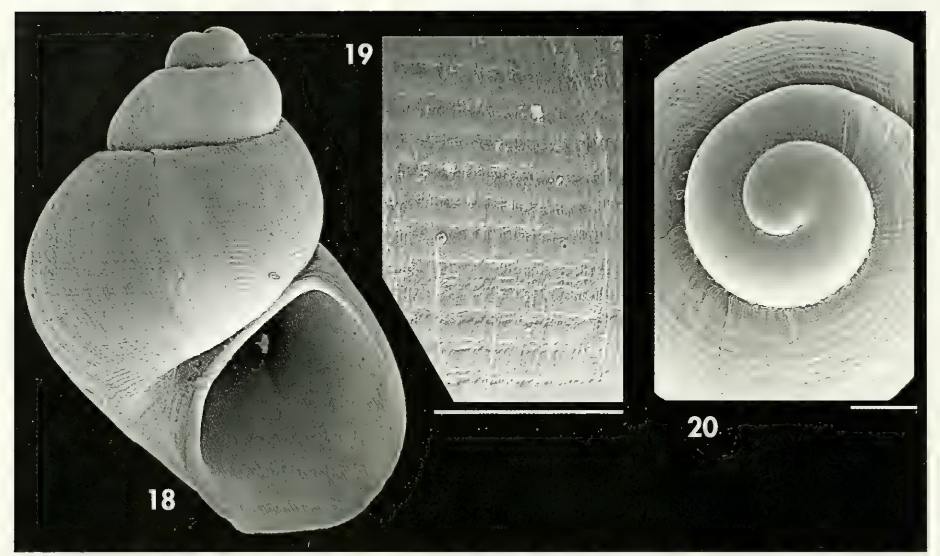
Dimensions: Holotype 1.9 mm in height.

Remarks: The widely spaced and sharply delimited grooves differentiate the present species from others in the genus *Elachisina*, particularly from *E.*



Figures 11-17. *Elachisina canarica* (Nordsieck and Garcia-Talavera, 1979). 11, 12: shells from La Restinga, Hierro (height 1.8 and 1.5 mm); 13: operculum (maximum diametre 0.6 mm). 14: microsculpture (same shell as 11); 15: protoconch, same locality; 16, 17: radula. Scale bars, 13-15: 100 µm; 16, 17: 20 µm.

Figuras 11-17. Elachisina canarica *(Nordsieck y Garcia-Talavera, 1979). 11, 12: conchas de La Restinga, Hierro (altura 1,8 y 1,5 mm); 13: opérculo (diámetro máximo 0,6 mm). 14: microescultura (misma concha que 11). 15: protoconcha, misma localidad; 16, 17: radula. Escalas, 13-15: 100 µm; 16-17: 20 µm.*

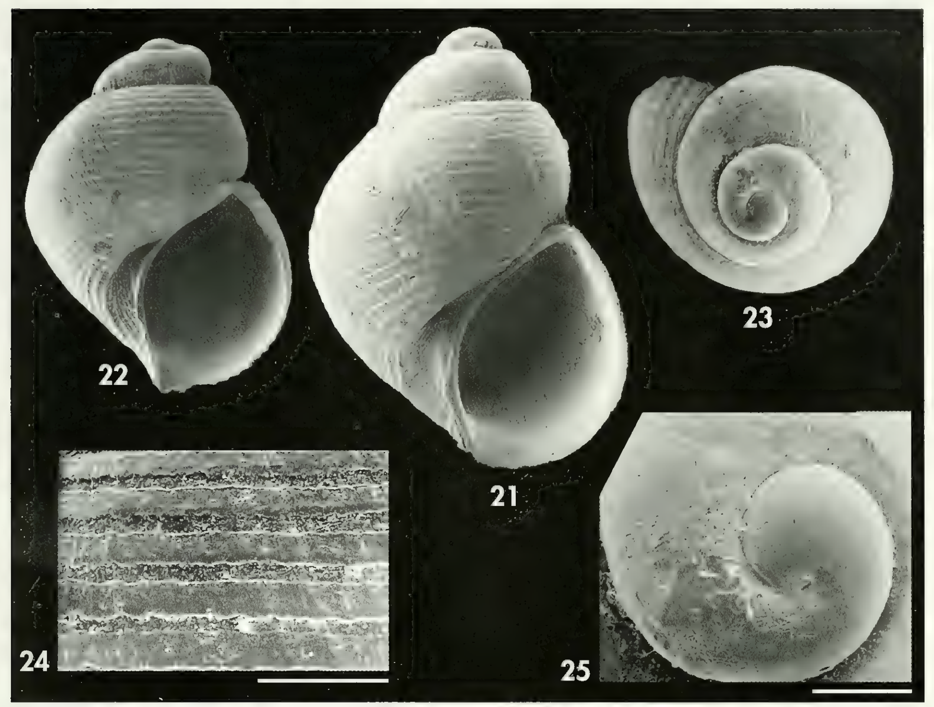


Figures 18-20. *Elachisina azoreana* spec. nov. 18: holotype from Santa Maria, Azores (MNHN; height 1.5 mm); 19: microsculpture of the holotype; 20: protoconch of a paratype. Scale bars 100 µm.
Figuras 18-20. E. azoreana. *18: holotipo de Santa Maria, Azores (MNHN: altura 1,5 mm); 19: microescultura del holotipo; 20: protoconcha de un paratipo. Escalas 100 µm.*

canarica, *E. azoreana*, *E. pelorcei* and *E. senegalensis*. *Elachisina floridana* is larger, with more whorls, a more tumid profile of the spire and a narrower umbilicus. *Elachisina pergrandis* and *E. tenuisculpta*, described below, have a protoconch with 2 whorls at least and have more numerous spiral grooves; the former also differs in having a nearly closed umbilicus in the adult stage.

Elachisina tenuisculpta spec. nov. (Figs. 26-35)

Type material: Holotype (Fig. 26) deposited in MNHN. Paratypes: AMNH (1), BMNH (1), MNCN (1, Fig. 16, nº 15.05/46460) CER (50), CFR (1), CPR (1), all from the type locality.
Other material examined: Mauritania: 1 s, Baie de Cansado, 20° 50′ N, 10 m (MNHN); 20 s, 10 j, 10 f, in intertidal sediments, Banc d'Arguin (CER); 2 s, intertidal, Baie de l'Etoile, Nouadhibou (CER). Senegal: 5 s, Dakar, on shipwreck "Le Tacoma", 15 m (CJP); 1 s, Grand Thiouriba, 40 m, (CJP); 1 s, 2 j, 2 f, Madeleines, Dakar, 6-14 m (CER). Guinea Bissau: 2 s, 2 f, S Ilha do Mel, Exp. "Chalgui II" sta. 7, 10° 41′ N, 15° 44.5′ W, 25 m (MNHN). Guinea Conakry: 1 j, W of Ile Kabak, "Sedigui I" sta. 154, 9° 18′ N, 14° 00′ W, 24 m (MNHN); 1 j, W Ile Tannah, "Sedigui I" sta. 80, 9° 12.3′ N 13° 37′ W, 16 m (MNHN); 1 j, W Rio Yomponi, "Sedigui II" sta. 688, 10° 24° N, 14° 50′ W, 22 m (MNHN); 1 j, W Ouendi-Taboria, "Chalgui 7" sta. 41, 9° 55′ N, 14° 17′ W, 17 m (MNHN); 2 s (CFR). Ghana: 6 s, 2 j, Miamia, 38-40 m (CER); 3 s, 22 j, 14 f, Cape Three Points, 45-60 m (CER). Gabon: 5 c, between Mayumba and Conkouati, "Congo", sta. 796, 17-19 m (MNHN). Angola: near Ambrizete, 7° 07′ S, 12° 21′ E, 80 m (MNHN); 154 s, Praia Etambar, Luanda, beach (MNHN); 4 s, 3 j, Ilha de Luanda, 10-20 m (MNHN); 4 s, off Luanda, 80-100 m, (CER); more than 130 j, off Mussulo, 90-100 m (MNHN); 1 s, Santo Antonio, Benguela (MNHN); 3 s, Caotinha, Benguela, infralittoral (MNHN); 1 s, Santa Maria, Lucira, 40 m (MNHN); 3 s, 1 j, São Nicolau (MNHN); 5 s, 5j, Praia Amelia, Namibe, 40-60 m (MNHN).
Type locality: Banc d'Arguin, Mauritania.
Etymology: The specific name alludes to the very fine sculpture of the shell.

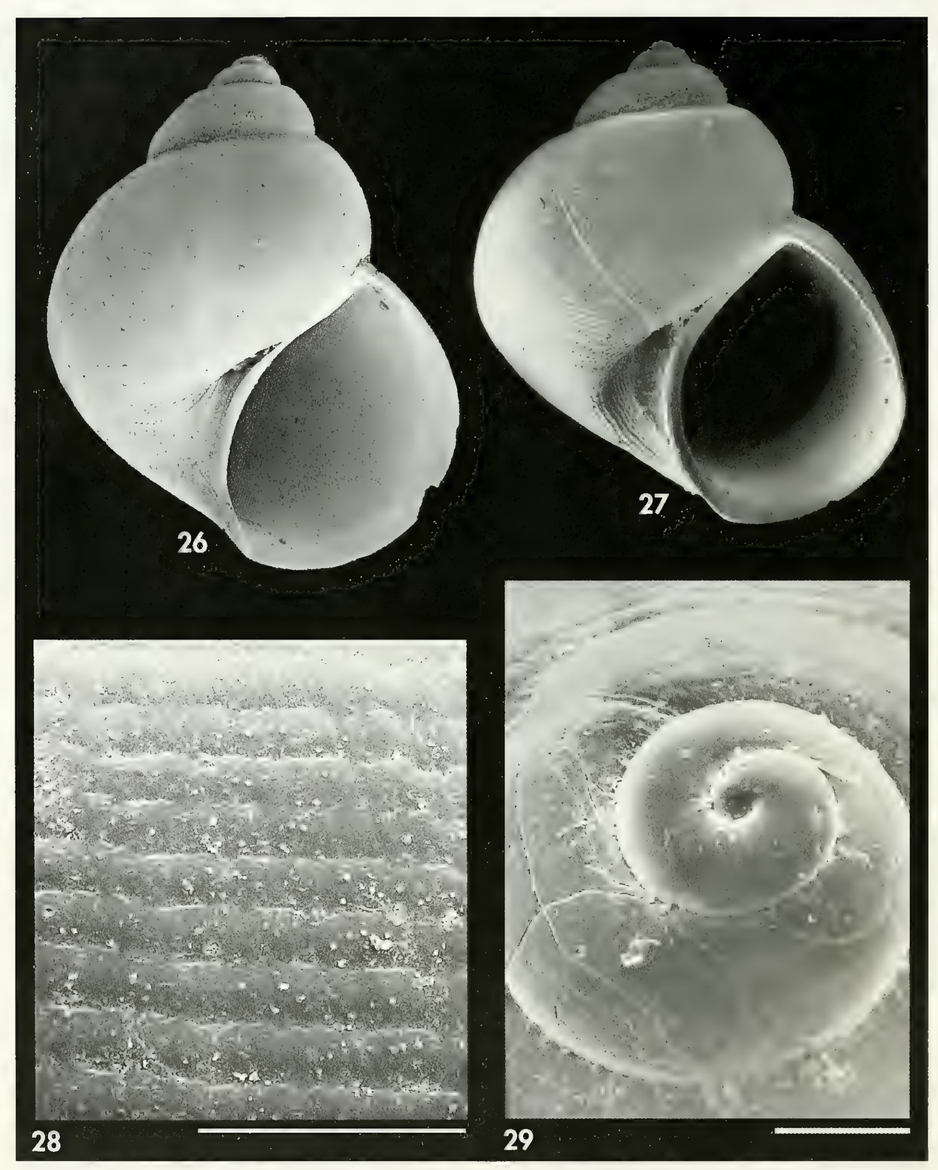


Figures 21-25. *Elachisina canaliculata* Rolán and Rubio, 2001. 21: holotype from Sal, Cape Verde Islands (MNCN; height 1.9 mm) 22, 23: paratype, same locality (MNHN, height 1.3 mm); 24: microsculpture (same paratype as 22, 23). 25: protoconch, same paratype. Scale bars 100 µm.
Figuras 21-25. Elachisina canaliculata *Rolán y Rubio, 2001. 21: holotipo de Sal, Islas de Cabo Verde (MNCN; altura 1,9 mm) 22, 23: paratipo, misma localidad (MNHN, altura 1,3 mm); 24: microescultura (mismo paratipo que 22, 23). 25: protoconcha, mismo paratipo. Escalas 100 µm.*

Description: Shell (Figs. 26, 27, 30, 32, 34-35) small, fragile, ovate to ovate-conic, with convex whorls and a deep suture. Protoconch of the type material (Fig. 29) with 2 whorls, dome-shaped, smooth, with a diameter of about 340 µm and a very small nucleus of about 35 µm. Protoconch (Figs. 29, 31, 33) in Angolan shells a little larger with 460 µm and between 2 1/4 and 2 1/2 whorls. Teleoconch of 2-2 1/4 convex whorls, transparent in fresh shells, sculptured with very numerous weak spiral grooves (Fig. 28), which are 10-12 in the beginning of the teleoconch, 15-18 in the second whorl and about 65-70 in the last whorl. There are about 35-40 between the suture and the insertion of the peristome, 25-30 between there and the umbilicus border and 8-12 inside the umbilicus). Spiral grooves 4 times narrower than interspaces, being slightly stronger near the umbilicus, and frequently very attenuated or almost disappeared on the upper part of the last whorl in adult shells. Umbilicus narrow, hardly developed in juvenile shells; with a faint rim situated well inside and terminating the spiral sculpture, then commarginal striae in its innermost part. Aperture ovate-piriform, with a blunt angulation in the adapical part, and with the abapical edge protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Colour white.

Dimensions: The holotype has 2.2 mm in heigth x 1.8 mm in diameter. The largest shell reaches 3.0 mm in height.

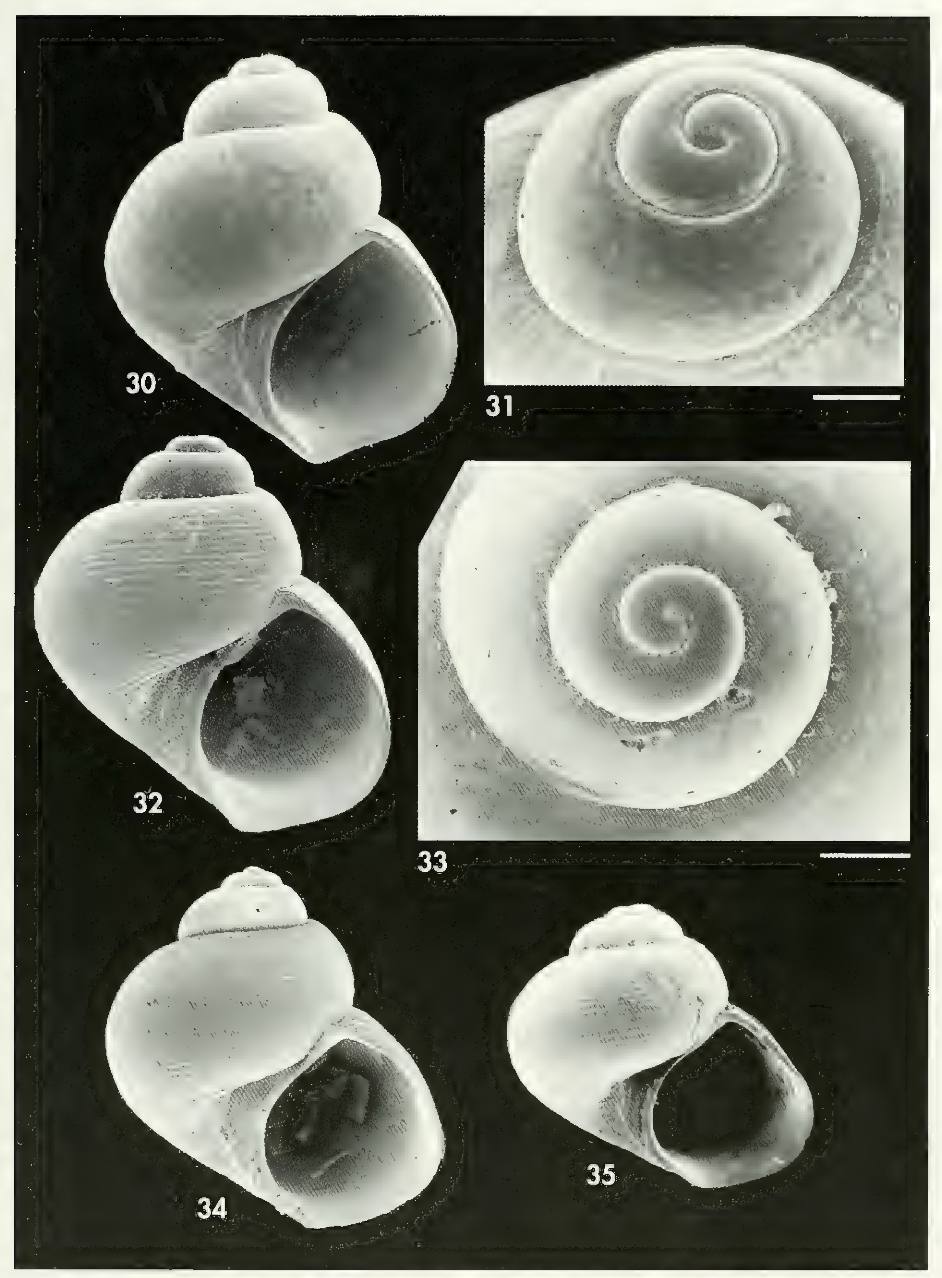
Distribution: Known from Mauritania to Angola, having been collected



Figures 26-29. *Elachisina tenuisculpta* spec. nov. 26: holotype from Banc d'Arguin, Mauritania (MNHN; height 2.2 mm); 27: paratype, same locality (MNCN; height 2.0 mm); 28: microsculpture of the holotype. 29: protoconch of a paratype, same locality (CER). Scale bars 100 µm.
Figuras 26-29. Elachisina tenuisculpta *spec. nov. 26: holotipo de Banc d'Arguin, Mauritania (MNHN; altura 2,2 mm); 27: paratipo, misma localidad (MNCN; altura 2,0 mm); 28: microescultura del holotipo. 29: protoconcha de un paratipo, misma localidad (CER). Escalas 100 µm.*

from Baie de l'Etoile in Nouadhibou to Banc d'Arguin, and also in Senegal, Guinea Bissau and Angola.

Remarks: We have found some differences between the shells from Mauritania and Senegal and those from Ghana



Figures 30-35. *Elachisina tenuisculpta* spec. nov. 30: shell from Miamia, Ghana (CER, height 1.15 mm); 31: protoconch, same locality, 32: shell from Guinea Conakry, trawled 60-80 m (CFR; height 1.09 mm); 33: protoconch of another shell from Guinea Conakry; 34-35: shells from off Luanda, 80-100 m, Angola (CER; height 1.19 and 0.86 mm). Scale bars 100 µm.

Figuras 30-35. Elachisina tenuisculpta *spec. nov. 30: concha de Miamia, Ghana (CER, altura 1,15 mm); 31: protoconcha, misma localidad, 32: concha de Guinea Conakry, rastreada en 60-80 m (CFR; altura 1,09 mm); 33: protoconcha de otra concha de Guinea Conakry; 34-35: conchas de frente a Luanda, 80-100 m, Angola (CER; altura 1,19 y 0,86 mm). Escalas 100 µm.*

to Angola. The specimens from the type locality are a little larger, the number of the spiral grooves is higher and the protoconch has 2 spiral whorls, whereas those from Angola have 2 1/4 or more whorls and, as a consecuence, a larger diameter. Anyway, shells from Senegal also had a protoconch similar to those from Angola, so that we considered that these differences could correspond to intraspecific variability of a species with a large distribution range. Therefore, we have included all of them in the same taxon.

Elachisina tenuisculpta resembles *E. catenata* spec. nov. which also has a multispiral protoconch and a globose shape, but the latter differs by a characteristic sculpture of spiral rows of pits. *Elachisina pergrandis* spec. nov. is also globose and also has a multispiral protoconch, but has much narrower and ragged spiral furrows, and a nearly closed umbilicus in the adult.

E. azoreana, *E. canarica*, *E. senegalensis* spec. nov. and *E. pelorcei* spec. nov. are smaller, more elongate, with fewer spiral grooves and have a paucispiral protoconch.

Elachisina pergrandis spec. nov. (Figs. 36-40)

Type material: Holotype (Fig. 36), deposited in MNHN and 22 paratypes: 2 s, Cabo Ledo, Luanda, 10-40 m (MNHN); 20 s, 2 j, Corimba Bay, 10-20 m (MNHN), Angola. Other paratypes: MNCN(1, nº 15.05/46461), CER (3), from type locality.

Other material examined: Senegal: 1 s, 13° 54′ N, 16° 49′ W, 7 m (MNHN). Guinea Conakry: W of Ouendi-Taboria, "Chalgui 7" sta. 41, 9° 55′ N, 14° 17′ W (MNHN). Ivory Coast: 7 s, region of Abidjan (MNHN). Ghana: 3 s, 10 j, Cape Three Points, 35-65 m; 5 j, Miamia, 38-40 m; 3 j, Miamia, 35 m; 1 s, 2 j, 1 f, Miamia, 45-50 m. Angola: 6 j, Ambrizete, Bango lighthouse, 07° 20.19′ S, 12° 55.09′ E, intertidal (MNHN); 2 j, Corimba Bay, 10-20 m (MNHN).

Type locality: Palmeirinhas, Luanda, Angola.

Etymology: The specific name alludes to being one of the largest species in the genus.

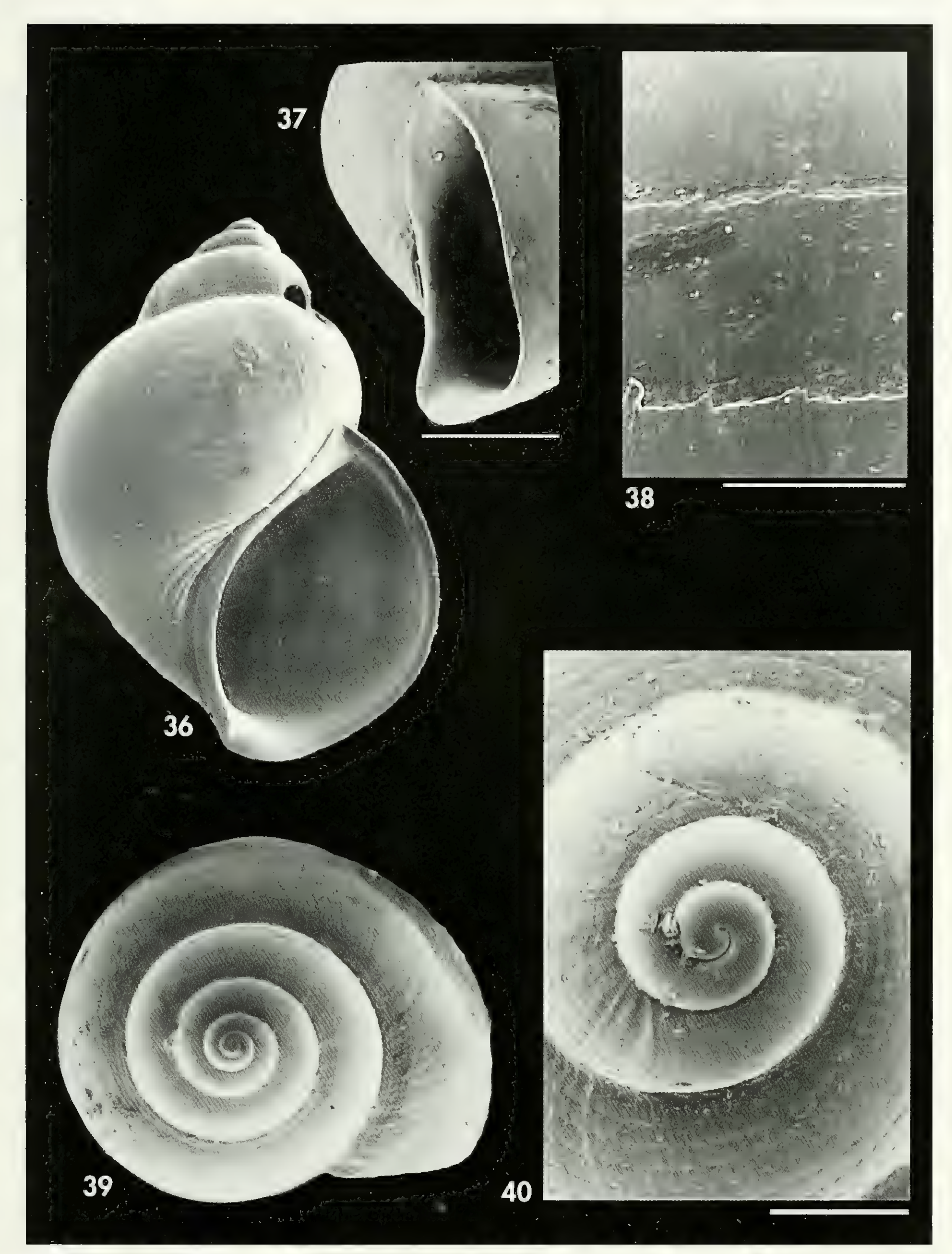
Description: Shell (Figs. 36, 37, 39) relatively large for the genus, ovate-conic, quite solid, with convex whorls. Protoconch (Fig. 40) of about 2 whorls, dome-shaped, smooth. Teleoconch of a little more than three whorls; these whorls are convex, shiny, opaque, and sculptured with some weak spiral grooves, sometimes interrupted so as to form a dashed pattern, and separated from each other by intervals 10 times as large as the grooves (Fig. 38). These are about 10 in the beginning of the teleoconch, 12 in the subsequent whorl and 14 on the last spire whorl. The last whorl has about 20-22 grooves, 14 in the subsutural area, very closely set, wheras the abapical area has a set of deeper furrows separating flat, blunt spiral cords around the umbilical chink. There is only a very narrow chink in place of the umbilicus. Aperture ovate piriform, with an angulation in the adapical part, and with the abapical edge strongly protruding at the abapical termination of the columella. Peristome continuous, with simple outer lip, slightly notched in the adapical angle (Fig. 36-37).

Dimensions: The holotype is 4.2 mm in heigth and 2.8 mm in width; the largest shells reach 4.5 mm in heigth.

Distribution: Known from Ghana to Luanda, Angola.

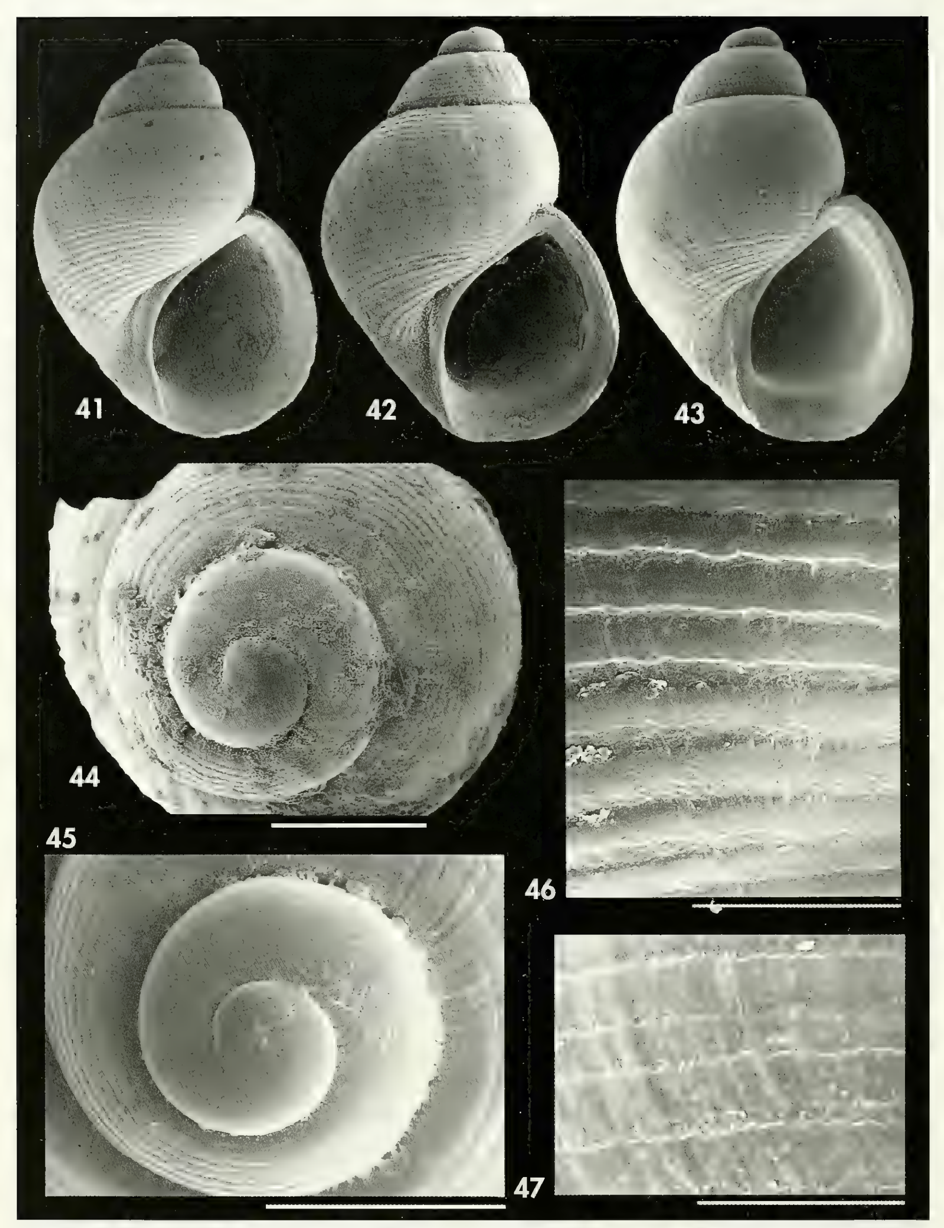
Remarks: This species resembles slightly *E. bakeri* (Strong, 1938) but the latter is more elongate, the sutures are not so deep, the spiral grooves are always more regular and the interspaces not so wide in the middle of the whorls.

Among the other East Atlantic species with multispiral protoconch, *E. tenuisculpta* spec. nov. and *E. catenata* spec. nov. differ in having a definite umbilicus, and *E. gubbiolii* spec. nov. in being more solid, more conical, with a peripheral angulation on the body whorl.



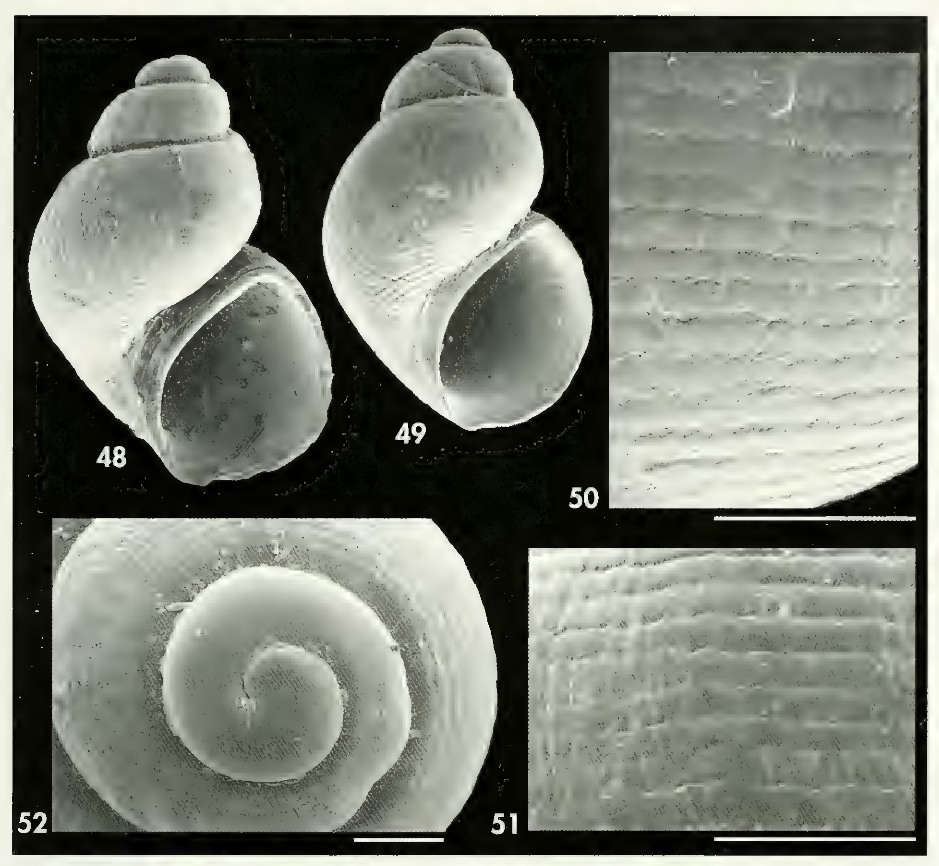
Figures 36-40. *Elachisina pergrandis* spec. nov. 36: holotype from Palmeirinhas, Luanda, Angola (MNHN; height 4.2 mm); 37: detail of the aperture of the holotype; 38: microsculpture of the holotype; 39: apical view of a paratype (CER; maximum diametre 3.0 mm); 40: protoconch, same paratype as 39. Scale bars, 37: 1mm, 38: 100 µm, 40: 200 µm.

Figuras 36-40. Elachisina pergrandis *spec. nov. 36: holotipo de Palmeirinhas, Luanda, Angola (MNHN; altura 4,2 mm); 37: detalle de la abertura del holotipo; 38: microescultura del holotipo; 39: vista apical de un paratipo (CER; diámetro máximo 3,0 mm); 40: protoconcha, mismo paratipo que 39. Escalas, 37: 1mm, 38: 100 µm, 40: 200 µm.*



Figures 41-47. *Elachisina pelorcei* spec. nov. 41: holotype from Petit Thiouriba, Dakar, Senegal (MNHN; height 1.6 mm); 42: paratype from Les Madeleines, Dakar, Senegal (MNCN; height 1.7 mm); 43: paratype from Grand Thiouriba (CER; height 1.7 mm); 44: protoconch of a juvenile from Petit Thiouriba (CER); 45: protoconch of a shell from Grand Thiouriba (CJP); 46, 47: microsculpture (same paratype as 42). Scale bars, 44, 45: 200 µm; 46, 47: 100 µm.

Figuras 41-47. Elachisina pelorcei *spec. nov. 41: holotipo de Petit Thiouriba, Dakar, Senegal (MNHN; altura 1,6 mm); 42: paratipo de Les Madeleines, Dakar, Senegal (MNCN; altura 1,7 mm); 43: paratipo de Grand Thiouriba (CER; altura 1,7 mm); 44: protoconcha de un juvenil de Petit Thiouriba (CER); 45: protoconcha de una concha de Grand Thiouriba (CJP); 46, 47: microescultura (mismo paratipo que 42). Escalas, 44, 45: 200 µm; 46, 47: 100 µm.*



Figures 48-52. *Elachisina senegalensis* spec. nov. 48: paratype from La Tacoma, Dakar (MNCN; height 1.4 mm); 49: holotype from Cap Vert, Dakar, Senegal (MNHN; height 1.2 mm); 50-51: microsculpture (same paratype as 48); 52: protoconch of another paratype from La Tacoma (CER). Scale bars 100 µm.

Figuras 48-52. Elachisina senegalensis *spec. nov. 48: paratipo de La Tacoma, Dakar (MNCN; altura 1,4 mm); 49: holotipo de Cap Vert, Dakar, Senegal (MNHN; altura 1,2 mm); 50-51: microescultura (mismo paratipo que 48); 52: protoconcha de otro paratipo de La Tacoma (CER). Escalas 100 µm.*

Elachisina pelorcei spec. nov. (Figs. 41-47)

Type material: Holotype (Fig. 41) deposited in MNHN (from Dakar, Petit Thiouriba, 33 m). Paratypes: in AMNH (1 s, Petit Thiouriba, 33 m, exCJP); BMNH (1, Dakar, Les Madeleines, 6-14 m), MNCN (1 s, nº 15.05/46362, Dakar, Les Madeleines, 7-13 m, exCJP), CER (1 s, Dakar, Grand Thiouriba, 40 m; 2 s, Petit Thioutiba, 33 m, exCJP; 14 s, Les Madeleines, 6-14 m); CJP (7 s, Grand Thiouriba, 40 m; 2 s, 1 j, Dakar, Goute Teni M'Both, 25 m; 4 s, Petit Thiouriba, 33 m; 2 s, Dakar, Almadies, 20-25 m), CFR (1, Les Madeleines, 6-14 m) and CPR (1, les Madeleines, 6-14 m).
Other material examined: Senegal: 1 s, 30 m, Les Madeleines (broken during the study); 6 s, 1 j, 1 f, Petit Thiouriba, 35 m (CER).
Type locality: Dakar, Senegal.
Etymology: The species is named after Jacques Pelorce, French malacologist who collected the first material of this species, and donated sediments where other shells were found.

Description: Shell (Figs. 41-43) very small, ovate to ovate-conic, relatively solid, with convex whorls. Protoconch (Figs. 44-45) of a little more than one smooth, shining whorl, dome-shaped in form and with a maximum diameter of about 280-295 µm and a nucleus with 106 µm. Teleoconch with 2 or 2 $^1/_4$ convex whorls, the first with 15 spiral grooves, and the last whorl with about 28. Spiral grooves even, with regular interspaces (Figs. 46-47), stronger near the abapical part and extending into the umbilicus. Umbilicus small, bearing inside a sharp ridge which terminates the external spiral sculpture. Aperture ovate-piriform, with a blunt angulation in the adapical part, and with the abapical edge very slightly protruding at the point where the umbilical keel meets the columella. Peristome continuous, with an internal thickening of the outer lip, and a beveled edge.

Dimensions: The holotype is 1.6 mm in height and 1.2 mm in width.

Distribution: Only known from Dakar, Senegal.

Remarks: *Elachisina azoreana, E. canarica* and *E. tenuisculpta* also have a paucispiral protoconch but have more fragile shells, with spiral sculpture more dense and with smaller grooves and wider umbilicus.

E. senegalensis, which is the most similar species and lives sympatrically, will be discussed below.

Elachisina senegalensis spec. nov. (Figs. 48-52)

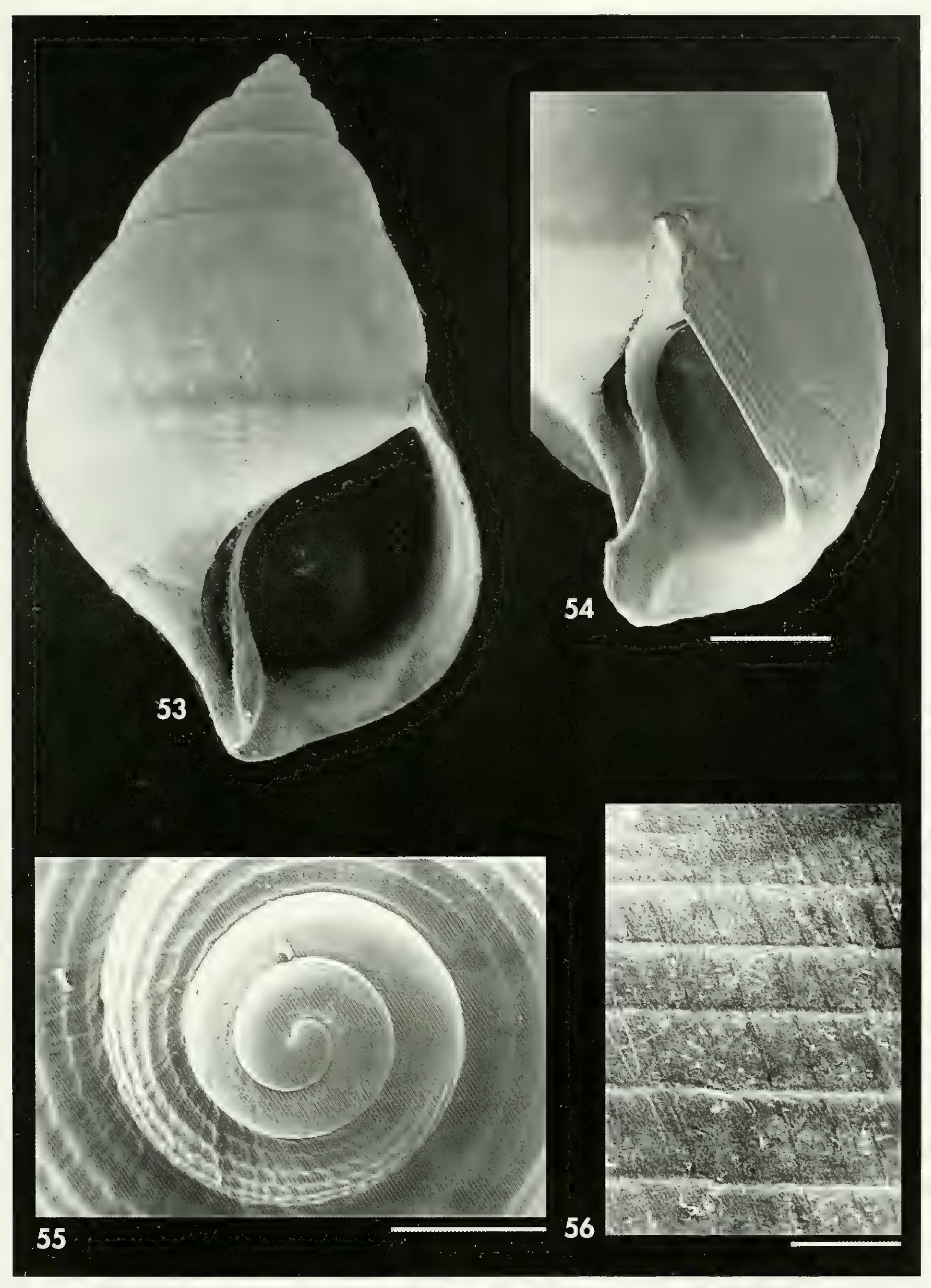
Type material: Holotype (Fig. 49) deposited in MNHN (Cap Vert, Dakar, Senegal). Paratypes: AMNH (1 s, Dakar, shipwreck of "La Tacoma", 15 m, exCJP), BMNH (1, Dakar, Les Madeleines, 6-14 m), MNCN (1 s, nº 15.05/46463, "La Tacoma", Fig. 48, ex CJP); in CER (1 s, "La Tacoma"; 12 s, Les Madeleines, 6-14 m); in CJP (2 s, "La Tacoma", 15 m, 3 s, Les Madeleines, 7-13 m,), CFR (1, Les Madeleines, 6-14 m), and CPR (1, Les Madeleines, 6-14 m).
Other material examined: Senegal: 1 s (broken during the study), "La Tacoma", 15 m; 4 f, Les Madeleines, 6-14 m (CER); 1 s, Dakar, on shipwreck, 12 m (CER); 2 j, Dakar, Tiwe, 35 m, (CER).
Type locality: Dakar, Senegal.
Etymology: The species is named after the area where it was collected.

Description: Shell (Figs. 48-49) very small, ovate to ovate-elongate, fragile, with convex whorls. Protoconch (Fig. 52) of a little more than one whorl, smooth and shiny, dome-shaped in form, and a maximum diameter of about 270 µm. Teleoconch with 2 or 2 $^1/_4$ convex whorls, the first with about 12 spiral grooves, the last whorl with about 33. Spiral grooves (Figs. 50, 51) even, with regular interspaces, a little stronger towards the abapical part and extending into the umbilicus. Umbilicus small, bearing inside a sharp ridge which terminates the external spiral sculpture, and with fine commarginal striae further inside. Aperture ovate-piriform, with an angulation in the adapical part, and with the abapical edge protruding at the point where the umbilical keel meets the columella. Peristome continuous, with simple outer lip. Columella slightly curved, the columellar edge of the aperture tending to separate from the preceding whorl in adults.

Dimensions: Holotype is 1.2 mm in heigh and 0.8 mm in width. Some shells can get 1.4 mm of maximum dimension.

Distribution: Only known from Dakar, Senegal.

Remarks: *Elachisina canarica* and *E. azoreana* are a little larger and more solid; also they have the protoconch wider, and have more spiral grooves. *E. pelorcei* is larger, more solid, and globose, with wider grooves, the umbilicus is more definite and the body whorl does not tend to separate from the previous whorl. Both species are found together, without intergrades.



Figures 53-56. *E. gubbiolii* spec. nov. 53: holotype from Dahkla, Sahara (MNCN; height 5.4 mm); 54: side view of the aperture of a paratype (CER; scale bars 1 mm); 55: protoconch of a paratype (MNHN; scale bar 200 µm); 56: microsculpture of the holotype. Scale bars 100 µm.
Figuras 53-56. E. gubbiolii *spec. nov. 53: holotipo de Dahkla, Sahara (MNCN; altura 5,4 mm); 54: vista lateral de la abertura de un paratipo (CER; barra de escala 1 mm); 55: protoconcha de un paratipo (MNHN; barra de escala 200 µm); 56: microescultura del holotipo. Escalas 100 µm.*

Elachisina gubbiolii spec. nov. (Figs. 53-56)

Type material: Holotype (Fig. 53) deposited in MNCN (nº 15.05/46464). Paratypes: in MNHN (1, Fig. 55), CER (1, Fig. 54) and CFG (4), all from type locality and ex CFG.
Other material examined: Only known from the type material.
Type locality: Dakhla, Sahara, 50-60 m.
Etymology: The specific name is after Franco Gubbioli, of Malaga, Spain, who provided the material of this species.

Description: Shell (Fig. 53) relatively large for the genus, ovate-conic, solid, with early spire whorls convex, the penultimate whorl only slightly convex and the body whorl bluntly angled at the periphery. Protoconch (Fig. 55) of 2 whorls, dome-shaped, smooth, with a small nucleus of about 56 µm and a diameter of about 375 µm. Teleoconch of about 4 whorls sculptured with weak spiral grooves, the first with about 5, stronger and wider grooves, the following with 6 grooves, then with an increasing number of grooves in the following. Spiral grooves on the first teleoconch whorl crossed by some folds which parallel the prosocline growth lines; spirals becoming weaker and narrower (about 1/15 of intervals) on the last whorl. There are about 32 grooves, 16 of them between the suture and the insertion of the aperture, and the remainder abapically to these; both groups separated by a smooth band, which is coincident with a weak peripheral angle. Spiral grooves fainter near the umbilicus, and are separated by larger interspaces in the upper part of the whorls (Fig. 56). Umbilicus narrow and deep, bordered by a sharp ridge overhanging an inner furrow. Aperture rhomboid, with a sharp angle in the adapical part, and with the abapical edge sharply protruding and notched at the termination of the columella (Fig. 54). Columella strongly twisted, almost vertical on its lower part.

Dimensions: The holotype is 5.4 mm in heigth and 3.5 mm in width. The largest shells can reach 7 mm in maximum dimension.

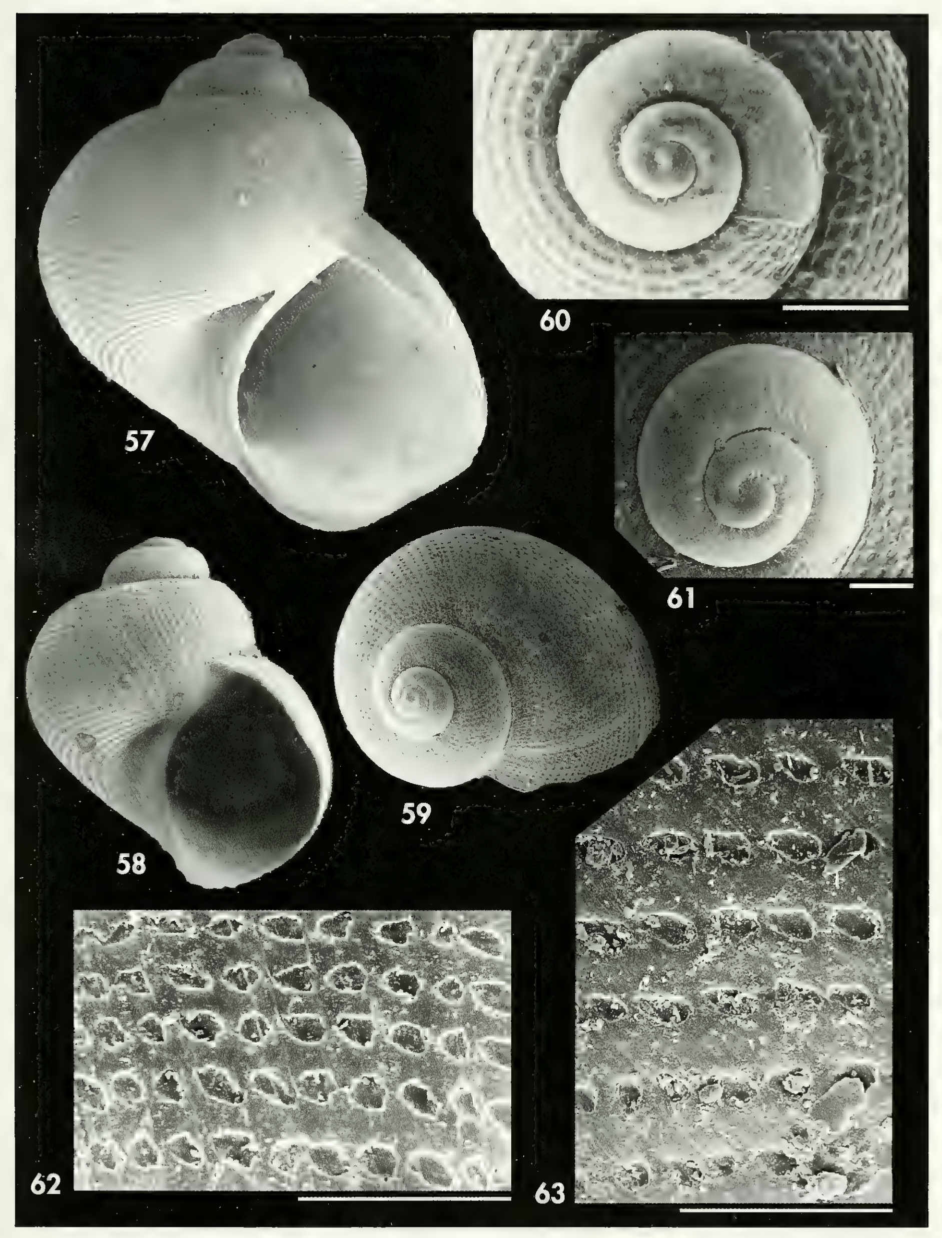
Distribution: Only known from the type locality.

Remarks: *E. gubbiolii* spec. nov. is distinctive, and differs from the other living species of the genus by its larger size, the peripherical angulation, the suture less deep and, over all, by its very protruding columella and basal notch similar to a siphonal canal. It resembles the fossil species *Pseudocirsope burdigalica* (Cossman and Peyrot, 1919), from the Miocene of Aquitaine Basin, France but the latter differs in a definitely stouter outline.

Elachisina catenata spec. nov. (Figs. 57-63)

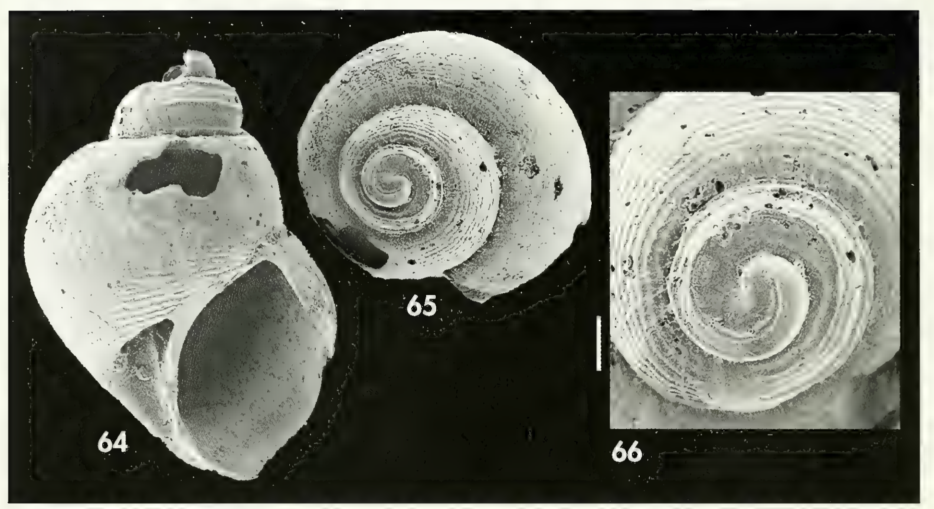
Type material: Holotype (Fig. 57) and 10 paratypes from the type locality, deposited in MNHN. Other paratypes: in MNCN (1, nº 15.05/46465, from Cacuaco, Angola); from Miamia, Ghana: in AMNH (1), CER (6, Figs. 58, 59), CFR (1) and CPR (1).
Other material examined: Ivory Coast: 2 s, Abidjan (MNHN). Ghana: 32 s, 28 j, 25 f, Cape Three Points, 35-65 m (CER); 9 s, 30 j, 8 f, Miamia, 45-50 m (CER); 1 s, Miamia, 35-40 m (CER). Angola: 1 s, Ambrizete, 07° 00′ S, 12° 20′ E, 60 m (MNHN); 4 s, Luanda, Corimba Bay, 10-20 m (MNHN); 1 j, off Mussulo, 50-70 m (MNHN); 10 j, 4 f, off Mussulo, 90-100 m (MNHN); 1 s, Palmeirinhas, 10 m.
Type locality: Mussulo, Luanda province, Angola.
Etymology: The specific name alludes the spiral sculpture which appears like formed by chains.

Description: Shell (Figs. 57-59) small, fragile, ovate to ovate-conic, umbilicate. Protoconch (Figs. 60-61) of a little more than 2 whorls which are dome-shaped and smooth, with 396 µm of diameter and a nucleus of 54 µm. Teleoconch of about 2-2 $^1/_2$ whorls, uniformly convex, with deeply impressed suture, sculptured with numerous, weak, spiral grooves. In first whorl there are 7 rows of irregu-



Figures 57-63. *Elachisina catenata* spec. nov. 57: holotype from Mussulo, Angola (MNHN; height 2.1 mm); 58: paratype from Miamia, Ghana (CER; height 1.3 mm); 59: paratype, same locality (CER; maximum diametre 1.8 mm); 60: protoconch of another paratype from Miamia; 61: protoconch (same paratype as 59). 62: microsculpture (same paratype as 58); 63: microsculpture of the holotype. Scale bars 100 µm.

Figuras 57-63. Elachisina catenata *spec. nov. 57: holotipo de Mussulo, Angola (MNHN; altura 2,1 mm); 58: paratipo de Miamia, Ghana (CER; altura 1,3 mm); 59: paratipo, misma localidad (CER; diámetro máximo 1,8 mm); 60: protoconcha de otro paratipo de Miamia; 61: protoconcha (mismo paratipo que 59); 62: microescultura (mismo paratipo que 57); 63: microescultura del holotipo. Escalas 100 µm.*



Figures 64-66. *Elachisina* sp. 64-65: shell from Palmeira, Cape Verde Islands (CER; height 1.83 mm); 66: protoconch. Scale bar 100 µm.

Figuras 64-66. Elachisina *sp. 64-65: concha de Palmeira, Islas de Cabo Verde (CER; altura 1.83 mm); 66: protoconcha. Escala 100 µm.*

lar, discrete pits (Figs. 62, 63); there are about 30 spiral grooves in the last whorl, and the pits become sunken inside the grooves. Umbilicus deep, not very wide, with fainter spiral grooves extending inside; the innermost part fluted by commarginal striae. Aperture ovate piriform, with a blunt angulation in the adapical part, and with the abapical edge hardly protruding at the point where the columella terminates. Peristome continuous, slightly prominent in the abapical part.

Dimensions: The holotype is 2.13 mm in heigth by 2.00 mm in diameter. The material from Ghana is of smaller size, with about 1.2-1.4 mm of maximum dimensions.

Distribution: Known from the Ivory Coast and Ghana to Angola.

Remarks: The present species differs from those previously mentioned by its globose form, by the absence of an umbilical keel, and especially by its distinctive sculpture of spiral discontinuous grooves formed by small pits.

Elachisina sp. (Figs. 64-66)

Material examined: 1 s, dredged in Palmeira, 30 m.

Description: Shell (Figs. 64, 65) small, ovate to ovate-conic, narrowly umbilicate, whorls convex sculptured with numerous, weak, spiral grooves. Protoconch (Fig. 66) with a little more than one whorl, dome-shaped, with a prominent cord running from the nucleus, and several ones which appear immediately after. Teleoconch similar to other of the genus.

Dimensions: 1.4 in heigth and 1.0 mm in width.

Distribution: Only known from Cape Verde archipelago, from where it is probably an endemic species.

Remarks: The sculpture of the protoconch separates this species from the other within the genus, which always have a smooth surface. We prefer not to name this species, considering that only a single, damaged shell is available.

Table I. Main characters for differenciation between the species presented in this work. Canal.: canaliculate.

Tabla I. Principales caracteres para la diferenciación entre las especies estudiadas en este trabajo. Canal.: acanalada.

	floridana	eritima	canarica	azoreana	canaliculata	tenuisculpta	pergrandis	pelorcei	senegalensis	gubbioli	catenata	sp.
Protoconch whorls	1 1/8	1 1/8	1 1/8 brown	1 1/8 brown	1 1/16	2	2	1 1/8	1 1/8	2 1/16	2 1/8	1
Protoconch sculpture	0	0	0	0	0	0	0	0	0	0	0	cords
µm of the nucleus of protoconch	120	125	91	109	120	34	40	106	85	56	54	110
µm on the protoconch	325	333	360	350	258	337-460	426	290	269	375	396	392
Teleoconch grooves	canal.	simple with a thread inside	simple with several threads	simple	canal.	simple very narrow	irregular very narrow	simple	simple	simple very narrow	formed by pits	simple
Number of striae in last whorl up to insertion of aperture	15	25	26	30	12	40	26	15	20	16	13	20
Shell	robust	robust	robust	medium	medium	fragile	medium	robust	medium	robust	fragile	fragile
Maximum size in mm	2.45	1.7	1.8	1.5	2.2	3.0	4.5	1.6	1.4	7.0	2.1	1.3

DISCUSION AND CONCLUSIONS

In the present work 12 species of the genus *Elachisina* are recorded from the Atlantic Ocean, of which only four were previously known: *Elachisina floridana* is the species present in the West Atlantic coast; *E. eritima* from Santa Helena Island is the only one known since the 19th century; *E. canarica* from the Canaries and *E. canaliculata* from the Cape Verde archipelago were described more recently. Seven species are described in the present work as new for science, and one more is kept unnamed until better material is obtained.

Three more species of the Atlanto-Mediterranean area have been suggested as belonging to *Elachisina*, or the Elachisinidae. One is *Elachisina versiliensis* Warén, Carrozza and Rocchini, 1990, a junior synonym of *Laeviphitus verduini* van Aartsen, Bogi and Giusti, 1989. This species has a strongly cancellate protoconch (see BOUCHET AND WARÉN, 1993: 705) reminiscent of the Nystiellinae (Epitoniidae) and very different from the planktotrophic protoconch type found in the Atlantic species of *Elachisina*. Moreover, it lacks the characteristic ridge bordering the umbilicus in all the species we have seen. For these reasons *Laeviphitus* was suggested in the original publication as a member of the Epitoniidae. This was rebutted by OKUTANI, FUJIKURA AND SASAKI (1993) who described an aditional species from a bathyal site off Japan and found a taenioglossate radula. WARÉN AND BOUCHET (2001) described another species *L. desbryueresi*

Table II. Distribution of the species of *Elachisina* from West African coast. Car: Caribbean; Azo: Azores; Can: Canary; CV: Cape Verde Islands; SH: Santa Helena; Sah: Sahara; Mau: Mauritania; Sen: Senegal; GC: Guinea Conakry; Gha: Ivory Coast and Ghana; Gui: Gulf of Guinea; Ang: Gabon and Angola.

Table II. Distribución de las especies de Elachisina *en la costa occidental africana. Car: Caribe; Azo: Azores; Can: Canarias; CV: Cabo Verde; SH: Santa Helena; Sah: Sáhara; Mau: Mauritania; Sen: Senegal; GC: Guinea Conakry; Gha: Costa de Marfil y Ghana; Gui: Golfo de Guinea; Ang: Gabón y Angola.*

	Car	SH	Can.	CV	Aço	Sah	Mau	Sen	GC	Gha	Gui	Ang
E. floridana	*											
E. eritima		*										
E. canarica			*									
E. canaliculata				*								
E. azoreana n.sp.					*							
E. tenuisculpta n. sp.							*	*	*	*		*
E. pergrandis n. sp.									*	*		*
E. pelorcei n. sp.								*				
E. gubbiolii n. sp.						*						
E. catenata n. sp.										*		*
E. senegalensis n. sp.								*				
E. sp.				*								

from the Mid Atlantic ridge and figured the taenioglossate radula. They also formally exclude it from Epitoniidae but agree that, awaiting an anatomical study, the systematic position of *Laeviphitus* remains uncertain.

"Cingula" globuloides Warén, 1972, from the Boreal North Atlantic, was transferred to *Elachisina* by WARÉN (1996). This is biogeographically discrepant with all the other *Elachisina*, restricted to tropical and warm temperate waters. The shell of *"C." globuloides* lacks the characteristic umbilical rim, and generic placement is pending confirmation with data on the living animals or radula.

Although most of the species have a similar aspect, some characters were found diagnostic with respect to the other congeneric. Some of these characters are summarized in the Table I.

The sizes of distribution ranges appear to be very uneven among the different species, although future records may extend the current ranges.

The five insular species are reported only from the respective islands or archipelagoes and are probably endemic. From their paucispiral protoconch with about 1 whorl, they are inferred to have non-planktotrophic larval development. These are *E. eretima* from St. Helena, *E. canarica* from the Canaries; *E. canaliculata* and *Elachisina* sp from Cape Verde archipelago; *E. azoreana* from the Azores.

There are three species which appear very localized on the mainland coast. *Elachisina gubbiolii*, recorded from the Sahara coast, can be inferred to have planktotrophic development and its apparently small range may be either an artifact due to sampling bias and rarity, or the result of ecological restriction (VERMEIJ, 1989). The two sympatric species *E. pelorcei* and *E. senegalensis* are restricted to the Dakar area. This small stretch of coastline is one of the few extensive sites with a rocky shore to be found on the West African coast, usually overcast with sediments. In this respect, it is ecologically an island and this is reflected in the local species richness and occurrence of short-range endemics (particularly spectacular in the genus *Conus*, see PIN AND LEUNG-TAK, 1995).

The other species (*E. tenuisculpta* and *E. pergrandis*) are known from larger areas along the West African coast as can be expected from their pattern of planktotrophic larval development. There is nevertheless a large gap in the Gulf of Guinea, which may reflect either a poor sampling in that area, or an adverse influence of the Niger Delta on marine communities.

The distribution area of the species is summarized in Table II.

Taking into account the new species described herein, West Africa appears as a center of high species richness for the family. This point must nevertheless be qualified, because Elachisinids are rather featureless gastropods. Species-rich areas such as the Indo-West Pacific may harbour even more species, either undescribed or misplaced in other molluscan families.

The habitat and mode of life of *Elachisina* species remains elusive. The West African species described here were never found alive, although some species being represented by a rather large number of shells, and other groups in the same samples were represented by a fair number of living specimens. Judging from the observations in the Caribbean, species of *Elachisina* may live under rocks, in crevices. This is consistent with the lack of colour pattern on the shells of all species. In West Africa however, the sampling of subtidal rock was underrepresentative, because of the lack of visibility and the lack of infrastructure for scuba-diving.

ACKNOWLEDGEMENTS

The authors extend thanks to the MNHN which loaned material for our study and the Project PARSYST which allowed us to see the collections and bibliography in this Museum. We are grateful to malacologists Colin Redfern, Winfried Engl, Franco Gubbioli, Jacques Pelorce, who sent material for study. Most SEM photographs were taken by Jesús Méndez of the CACTI, University of Vigo. We are grateful to Pierre Lozouet (MNHN, Paris) for access to relevant fossil material from the Oligocene and Miocene of France and for helpful advice on Tertiary elachisinids; to Anselmo Peñas for fossil material from La Pedrera, NE Spain.

The first author acknowledges the grant PGIDTOOPXI30121PR of the Xunta de Galicia.

BIBLIOGRAPHY

BOUCHET, P. AND WARÉN, A., 1993. Revision of the Northeast Atlantic bathyal and abyssal Mesogastropoda. *Bollettino Malacologico*, supplemento 3: 579-840.

DALL, W. H., 1918. Changes in and additions to molluscan nomenclature. *Proceedings ot the Biological Society of Washington*, 31: 137-138.

NORDSIECK, F. AND GARCÍA-TALAVERA, F., 1979. *Moluscos marinos de Canarias y Madera (Gastropoda)*. Aula de Cultura de Tenerife, 208 pp, 46 pls.

OKUTANI, T., FUJIKURA, K. AND SASAKI, T., 1993. New taxa and new distribution records of deep-sea gastropods collected from or near chemosynthetic communities in the Japanese waters. *Bulletin of the National Science Museum, Tokyo, ser. A*, 19 (4): 123-143.

PIN, M. AND LEUNG-TAK, K. D., 1995. Cones of Senegal. *La Conchiglia*, supplement to issue 277: 4-55.

PONDER, W. F., 1985a. The anatomy and relationships of *Elachisina* Dall (Gastropoda: Rissoacea). *Journal of Molluscan Studies*, 51: 23-34.

PONDER, W. F., 1985b. A review of the genera of Rissoidae (Mollusca: Mesogastropoda: Rissoacea). *Records of the Australian Museum*, suppl. 4: 1-221.

REHDER, H. A., 1943a. New marine mollusks from the Antillean region. *Proceedings of the United States National Museum*, 93 (3161): 187-203, pls. 19-20.

REHDER, H. A., 1943b. Corrections and ecological notes on some recently described Florida marine shells. *The Nautilus*, 57 (1): 32-33.

SMITH, E. A., 1890. Report on the Marine Molluscan Fauna of St. Helena. *Proceedings of the Zoological Society*, 18: 247-317, pls. 21-24.

van Aartsen, J.J., Bogi, C. and Giusti F., 1989. Remarks on the genus *Benthonella* (Rissoidae) in Europe, and the description of *Laeviphitus* (nov.gen.) *verduini* (nov.spec.) (Epitoniidae). *La Conchiglia*, 246-249: 19-22.

Vermeij, G.J., 1989. Geographical restriction as a guide to the causes of extinction: the case of the cold northern oceans during the Neogene. *Paleobiology*, 15: 335-356.

Warén, A., 1996. New and little known mollusca from Iceland and Scandinavia. Part 3. *Sarsia*, 81: 197-245.

Warén, A. and Bouchet, P., 2001. Gastropoda and Monoplacophora from hydrothermal vents and seeps new taxa and records. *The Veliger*, 44 (2): 116-227.

Warén, A., Carrozza, F. and Rocchini, R., 1990. *Elachisina versiliensis*, a new Mediterranean species of the family Elachisinidae (Prosobranchia, Truncatelloidea). *Bollettino Malacologico*, 25: 335-339.

© Sociedad Española de Malacología —————— Iberus, 21 (2): 91-98, 2003

Description of a new muricopsine species (Gastropoda: Muricidae) from the Southwestern Indian Ocean

Descripción de una nueva especie de muricopsine (Gastropoda: Muricidae) del suroesta del Océano Índico

Roland HOUART*

Recibido el 10-II-2003. Aceptado el 24-IV-2003

ABSTRACT

Favartia marianae n. sp. is described from Zululand, South Africa with range extension to South Mozambique. It is compared with *Favartia maculata* (Reeve, 1845), *F. cecalupoi* Bozzetti, 1993, *F. jeanae* Bertsch and D'Attilio, 1980, and *F. conleyi* Houart, 1999. *Murex mundus* Reeve, 1849 is here proposed as a *nomen dubium*.

RESUMEN

Se describe *Favartia marianae* spec. nov. de Zululand, Suráfrica con una distribución hasta el sur de Mozambique. La nueva especie se compara con *Favartia maculata* (Reeve, 1845), *F. cecalupoi* Bozzetti, 1993, *F. jeanae* Bertsch and D'Attilio, 1980, and *F. conleyi* Houart, 1999. Se propone que el taxon *Murex mundus* Reeve, 1849 sea considerado *nomen dubium*.

KEY WORDS: Gastropoda, Muricidae, Muricopsinae, Southwestern Indian Ocean, *Favartia* n. sp.
PALABRAS CLAVE: Gastropoda, Muricidae, Muricopsinae, suroeste del Océano Índico, *Favartia* spec. nov.

INTRODUCTION

Since both reviews of Muricidae by FAIR (1976) and by RADWIN and D'ATTILIO (1976), several muricids from Zululand (South Africa) and Mozambique have been described by VOKES (1978), HOUART (1986, 1990, 1994, 1995, 1998, 1999) and by PONDER and VOKES (1988). Other new discoveries have also extended the geographical distribution of many species originally known from South Africa or from other localities throughout the Indian Ocean, to Mozambique (unpublished).

Another small muricid species occurring off Zululand and Mozambique, sent to me for identification, remained unidentified in one of my drawers for a couple of years. New material obtained recently allowed a better comparison with other species and has led to its description as a new species.

Abbreviations:

BM (NH): Natural History Museum, London, U.K.
IRSNB: Institut royal des Sciences naturelles de Belgique, Bruxelles, Belgium.
MNHN: Muséum national d'Histoire naturelle, Paris, France.

Table I. Terminology employed in the present paper with acronyms used in the descriptions (after MERLE, 2001): see Figures 1-3.
Tabla I. Terminología empleada en el presente trabajo con los acrónimos utilizados en las descripciones (según MERLE, 2001): véanse las Figuras 1-3.

SHOULDER	
IP	infrasutural primary cord (primary cord on shoulder)
adis	adapical infrasutural secondary cord (adapical to IP)
abis	abapical infrasutural secondary cord (abapical to IP -between IP and P1-)
CONVEX PART OF THE TELEOCONCH WHORL AND SIPHONAL CANAL	
P1	shoulder primary cord
P2-P6	primary cords of convex part of teleoconch whorl
s1-s6	secondary cords
tad	tertiary adapical cord
tab	tertiary abapical cord
ADP	adapical siphonal primary cord
MP	median siphonal primary cord
APERTURE	
ID	infrasutural denticle
D1-D5	denticles of the convex part of the teleoconch whorl

NM: Natal Museum, Pietermaritzburg, South Africa.
Terminology: full list given in Figures 1-3 and Table I.

The acronyms are occasionally put between parentheses, meaning that the character was observed in a few cases but not in all specimens.

SYSTEMATICS

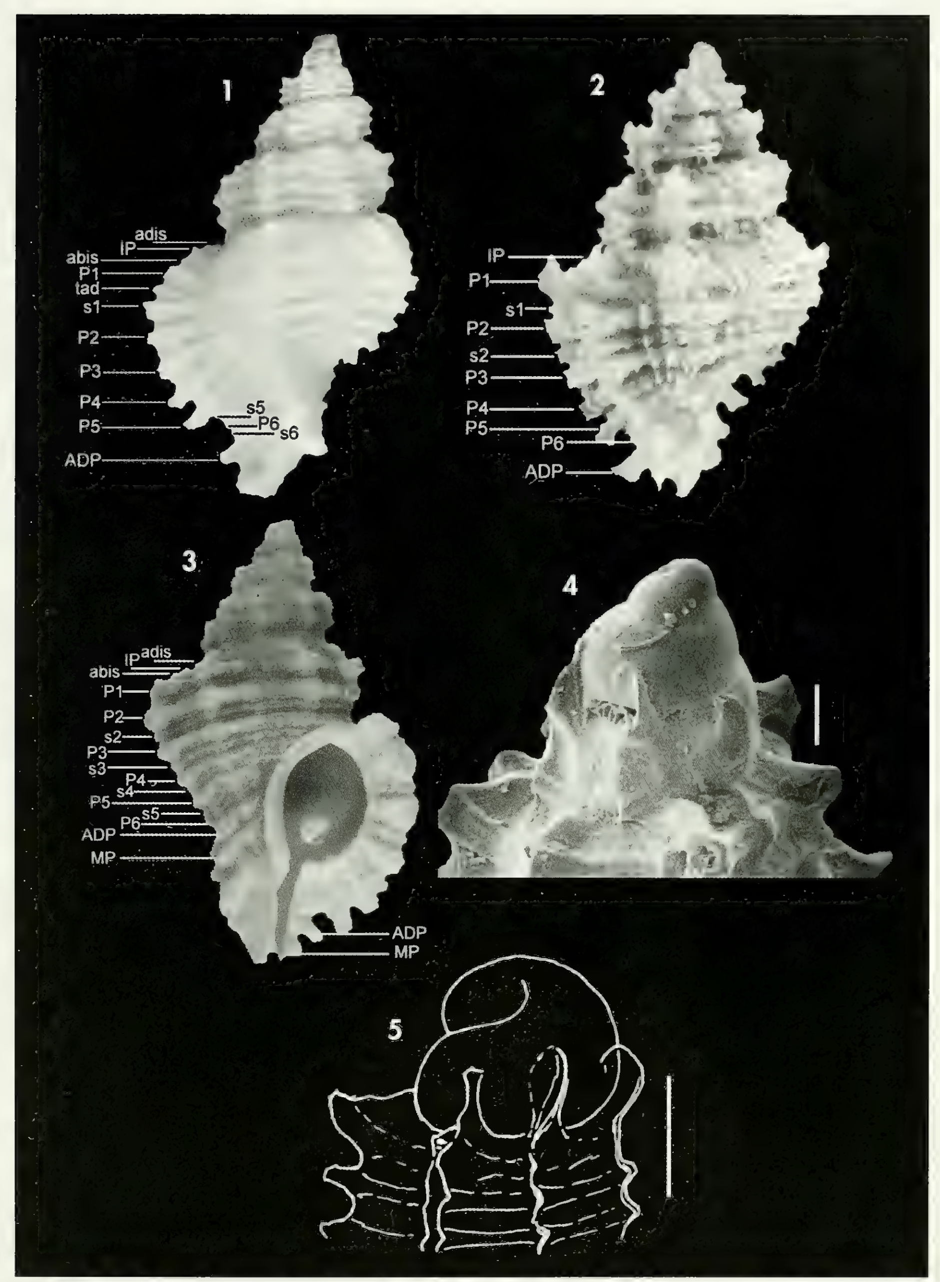
Family MURICIDAE Rafinesque, 1815
Subfamily MURICOPSINAE Radwin and D'Attilio, 1971
Genus *Favartia* Jousseaume, 1880

Type species, by original designation: *Murex breviculus* Sowerby, 1834, Recent, Indo-West Pacific.

Favartia marianae n. sp. (Figs. 1, 5-8)

Type material: South Africa, N Zululand, off Jesser Point, 27°35.0′ S, 32°41.8′ E, 70 m, dredged Meiring Naudé, 9.VI.87, holotype NMSA D8542/T1937.
Paratypes: South Mozambique, between Quissico and Zavora Point, 90-120 m, 2 C.P. Fernandes; 85-95 m, 1 R. Houart; 75-145 m, 1 Institut royal des Sciences naturelles de Belgique IG 29829/515; 1 MNHN; 2 J. Rosado, 3 R. Houart.
Type locality: South Africa, N Zululand, off Jesser Point, 27°35.0′ S, 32°41.8′ E, 70 m.
Distribution: North Zululand (South Africa) to South Mozambique, living at 70-90 m.
Etymology: This new species is named for Mariana, granddaughter of César P. Fernandes (Cascais, Portugal).

Description: Shell small for the genus, up to 11.17 mm in length (paratype C.P. Fernandes) (holotype 7.15 mm), lanceolate, lightly spinose. Spire high with 1.25-1.5 protoconch whorls (1.5 whorls in holotype) and up to 5 convex, weakly



Figures 1-3. Spiral sculpture. 1: *Favartia marianae* n.sp.; 2: *F. conleyi* Houart, 1999; 3: *F. cecalupoi* Bozzetti, 1993. Figures 4, 5. Protoconchs. 4: *F. jeanae* Bertsch and D'Attilio, 1980, Sulu Sea, Philippine Islands. Coll. R. Houart. Scale bar: 0.2 mm; 5: *F. marianae* n.sp., South Mozambique, between Quissico and Zavora Point, 90-120 m, paratype coll. R. Houart. Scale bar: 0.5 mm.

Figuras 1-3. Escultura espiral. 1: Favartia marianae *spec. nov.; 2:* F. conleyi *Houart, 1999; 3:* F. cecalupoi *Bozzetti, 1993. Figuras 4, 5. Protoconchas. 4:* F. jeanae *Bertsch y D'Attilio, 1980, Sulu Sea, Philippine Islands. Coll. R. Houart. Scale bar: 0,2 mm; 5: F. marianae n.sp., South Mozambique, entre Quissico y Zavora Point, 90-120 m, paratipo coll. R. Houart. Escala gráfica: 0,5 mm.*

shouldered teleoconch whorls. Suture impressed. Protoconch large and broad; whorls rounded, smooth, glossy; terminal varix thin, raised, weakly curved.

Axial sculpture of teleoconch whorls consisting of moderately high, weakly spinose varices, each with short, broad, primary and secondary spines. First whorl with 6 or 7 varices (7 in holotype), 7 on second, 7 or 8 on third (8 in holotype), 6-8 on penultimate (6 in holotype), 5 on last whorl. Other axial sculpture of low growth lamellae, forming small scales on spiral cords.

Spiral sculpture of strong, low, weakly squamose cords. First whorl with visible P1-P2, occasionally starting s1, second with P1, s1, P2, third and fourth with adis, IP, abis, P1, s1, P2, P3 (P3 partly covered by next whorl), last whorl with adis, IP, abis, P1, (tad), s1, (tab), P2, P3, P4, P5, s5, P6, s6, ADP, (MP). P1-P5, s1, and ADP ending as short open spines on axial varices; s1 similar to primary cords; P6 strongly reduced.

Aperture small, broadly ovate. Columellar lip narrow, flaring, smooth, occasionally with a small narrow knob abapically, rim partially erect, adherent at adapical extremity. Anal notch shallow, broad. Outer apertural lip weakly erect with weak denticles within: ID obsolete or very shallow, D1-D5 increasing in strength abapically.

Siphonal canal short, broad, dorsally bent at tip, open.

Shell white, salmon or light orange, axial ribs and siphonal canal paler in coloured specimens; inside of aperture white, light pink or light salmon. Operculum and radula unknown.

Remarks: *Favartia maculata* (Reeve, 1845) (Figs. 9-11), known from throughout the Indo-Pacific, differs in having more indented whorls and a different spiral sculpture morphology, the last teleoconch whorl of *F. maculata* having P1 and P2 never separated by a strong s1; however the presence of a more or less high s2 is observed in some specimens. The convex part of the last teleoconch whorl of *F. maculata* usually having following sculpture: P1, P2, (s2), P3, (s3), P4, P5 (P6 absent or strongly reduced). Moreover, the protoconch of *F. maculata* is conical with 3.5 whorls and a sinusigera type terminal varix.

F. cecalupoi Bozzetti, 1993 (Figs. 3,12) has a broader last teleoconch whorl compared to the previous whorls, lower axial ribs, stronger primary spiral cords, and a broader aperture. It also differs in having higher, almost similar P1-P5. The spiral sculpture morphology of the last teleoconch whorl in *F. cecalupoi* being: adis, IP,

(Right page) Figures 6-8. *Favartia marianae* n.sp.; 6: from South Africa, N. Zululand: off Jesser Point, 27°35.0' S, 32°41.8' E, 70 m, holotype NM D8542/ T1937, 7.15 mm; 7-8: Mozambique, between Quissico and Zavora Point, 90-120 m, paratype coll. C.P. Fernandes, 11.17 mm. Figures 9-11. *Favartia maculata* (Reeve, 1845). 9: Holotype of Murex salmonea Melvill and Standen, 1899, Torres Strait, Queensland, Australia, BM (NH) 1899.2.23.24, 12 mm; 10: shell from South Africa, N Zululand, off Kosi River Mouth, 26°53.9' S, 32°55.5' E, 50 m, NM D6855, 18.9 mm; 11: syntype of *Murex maculatus* Reeve, 1845, unknown locality, BM (NH) 1972020, 16.1 mm. Figure 12. *Favartia cecalupoi* Bozzetti, 1993, off Ras Hafun, 150 km south of Guarda Fadui, Northeastern Somalia, 200-250 m, holotype IRSNB 27882/455, 14 mm.

(Página derecha) Figuras 6-8. Favartia marianae *spec. nov.; 6: de Suráfrica, N. Zululand: fuera de Jesser Point, 27°35.0' S, 32°41.8' E, 70 m, holotipo NM D8542/ T1937, 7,15 mm; 7-8: Mozambique, entre Quissico y Zavora Point, 90-120 m, paratipo col. C.P. Fernandes, 11,17 mm. Figuras 9-11.* Favartia maculata *(Reeve, 1845). 9: holotipo de* Murex salmonea *Melvill y Standen, 1899, Torres Strait, Queensland, Australia, BM (NH) 1899.2.23.24, 12 mm; 10: concha de South Africa, N Zululand, fuera de Kosi River Mouth, 26°53,9' S, 32°55,5' E, 50 m, NM D6855, 18,9 mm; 11: sintipo de* Murex maculatus *Reeve, 1845, localidad desconocida, BM (NH) 1972020, 16,1 mm. Figura 12.* Favartia cecalupoi *Bozzetti, 1993, fuera de Ras Hafun, 150 km al sur de Guarda Fadui, nordeste de Somalia, 200-250 m, holotipo IRSNB 27882/455, 14 mm.*


6
7
8
9
10
11
12

abis, P1, P2, (s2), P3, (s3), P4, (s4), P5, P6 (reduced or absent), ADP, MP.

F. jeanae Bertsch and D'Attilio, 1980 (Figs. 4, 13-15) is more slender with a higher spire, stronger axial ribs, and conical multispiral protoconch consisting of 3-3.5 whorls, ending with a sinusigeral type terminal varix (Fig. 4). *F. jeanae* resembles species currently included in *Caribiella* Perriliat, 1972 from Tropical America. However, I am of the opinion that both taxa, *Favartia* and *Caribiella*, are congeneric.

F. conleyi Houart, 1999 (Figs. 2, 17-19) described from Guam but also occurring in New Caledonia and the Society Islands, differs in having a shell with more shouldered whorls, more squamose spiral cords, and a shorter siphonal canal, strongly recurved at tip. *F. conleyi* also has a different spiral sculpture morphology in having IP, P1-P5, (P6), ADP. Last whorl occasionally with narrow s1 and s2; IP, P1-P5 and ADP strong, high; P6 reduced or absent.

The holotype of *Murex mundus* Reeve, 1849 [new name for *M. exiguus* Reeve, 1849 (not Broderip, 1833)] also resembles the new species. Although this unique type specimen can easily be ascribed to the genus *Favartia*, it is beachworn, probably subadult, and lacks the protoconch and the first teleoconch whorl. The actual identity of *Favartia munda* (Reeve, 1849) remains thus uncertain - it has been considered a synonym of *F. pelepili* D'Attilio and Bertsch, 1980 by VOKES (1985) - and is here maintained as a *nomen dubium*. I cannot apply to the new species that is not known from the intensively explored Philippines.

ACKNOWLEDGEMENTS

My deepest thanks to C. P. Fernandes, Cascais, Portugal, J. Rosadoi, Almada, Portugal, and R. N. Kilburn, Doctor Emeritus at the Natal Museum for the loan and gift of material, to J. Cilis, Institut royal des Sciences naturelles de Belgique, for SEM photograph of the protoconch of *F. jeanae*, and to John Wolff (Lancaster, USA) for his comments and corrections of the English text.

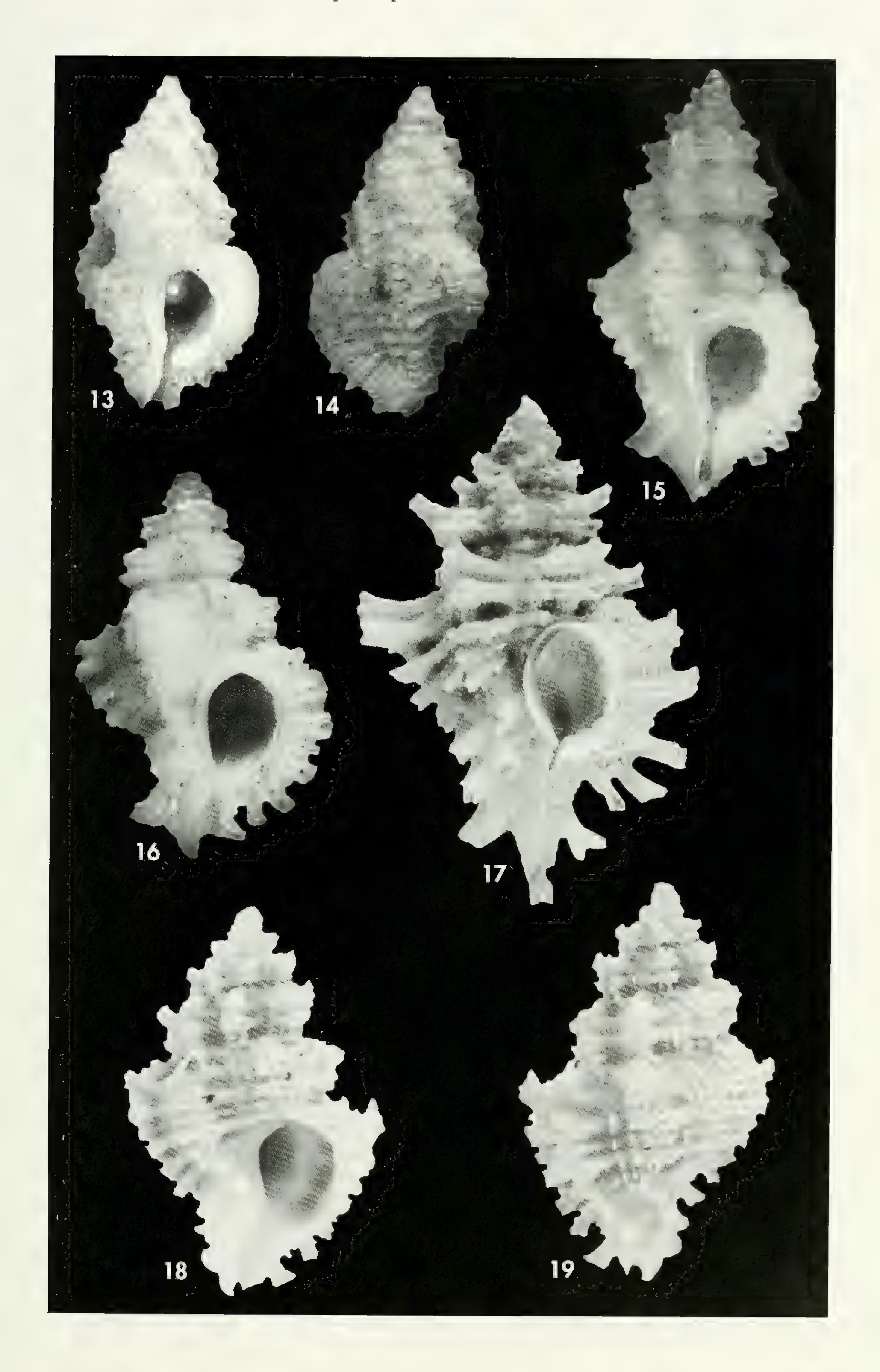
BIBLIOGRAPHY

FAIR, R. H., 1976. *The* Murex *Book, an illustrated catalogue of Recent Muricidae (Muricinae, Muricopsinae, Ocenebrinae)*. Sturgis Printing Co., Honolulu, Hawaii, 138 pp.

HOUART, R., 1986. *Chicoreus (Naquetia) triqueter vokesae* subsp. nov., a new name for a misidentified species (Gastropoda: Muricidae). *Apex*, 1 (3): 95-96.

(Right page) Figures 13-15. Favartia jeanae Bertsch and D'Attilio, 1980. 13, 14: Holotype of *Murex pumilus* A. Adams, 1853 (not *M. pumilus* Broderip, 1833), China Seas, holotype BM (NH) 197466, 8.1 mm; 15. shell from Philippine Islands, Cebu, Punta Engaño, 110 m, coll. R. Houart, 9 mm. *Figure 16. Murex mundus* Reeve, 1849, Philippine Islands, holotype BM (NH) 1972018, 11 mm. *Figures 17-19. Favartia conleyi* Houart, 1999. 17: Guam, Pity Lagoon, among silty dead coral, 1.5-2.5 m, holotype MNHN, 15.2 mm; 18-19: New Caledonia, 19°08' S, 163°29' E, 65-120 m, MNHN, 11.9 mm.

(Página derecha) Figuras 13-15. Favartia jeanae *Bertsch and D'Attilio, 1980. 13, 14: holotipo de* Murex pumilus *A. Adams, 1853 (not* M. pumilus *Broderip, 1833), mares de China, holotipo BM (NH) 197466, 8,1 mm; 15: concha de Islas Filipinas, Cebu, Punta Engaño, 110 m, col. R. Houart, 9 mm. Figura 16.* Murex mundus *Reeve, 1849, Islas Filipinas, holotipo BM (NH) 1972018, 11 mm. Figuras 17-19.* Favartia conleyi *Houart, 1999. 17: Guam, Pity Lagoon, entre sedimentos de coral muerto, 1,5-2,5 m, holotipo MNHN, 15,2 mm; 18-19: concha de Nueva Caledonia, 19°08' S, 163°29' E, 65-120 m, MNHN, 11,9 mm.*


13
14
15
16
17
18
19

HOUART, R., 1990. New taxa and new records of Indo-Pacific species of *Murex* and *Haustellum* (Gastropoda, Muricidae, Muricinae). *Bulletin du Muséum national d'Histoire naturelle*, Paris, 4° sér., 12, sect A, n° 2: 329-347.

HOUART, R., 1994. Description of a new species of Typhinae (Muricidae) from the Western Indian Ocean. *Annals of the Natal Museum*, 35: 153-155.

HOUART, R., 1995. The Ergalataxinae (Gastropoda, Muricidae) from the New Caledonia region with some comments on the subfamily and the description of thirteen new species from the Indo-West Pacific. *Bulletin du Muséum national d'Histoire naturelle*, Paris, 4e sér., 16, section A, n° 2-4: 245-197.

HOUART, R., 1998. Description of eight new species of Muricidae (Gastropoda). *Apex*, 13 (3): 95-109.

HOUART, R., 1999. Description of two new species of Muricidae (Gastropoda) from Mozambique, East Africa, and range extension of *Chicoreus (Triplex) elisae* Bozzetti, 1991. *Iberus*, 17 (2): 123-130.

MERLE, D., 2001. The spiral cords and the internal denticles of the outer lip in the Muricidae: terminology and methodological comments. *Novapex*, 2 (3): 69-91.

PONDER, W. F. AND VOKES, E. H., 1988. Revision of the Indo-West Pacific fossil and Recent species of *Murex* s.s. and *Haustellum* (Mollusca: Gastropoda: Muricidae). *Records of the Australian Museum*, suppl. 8: 1-160.

RADWIN G. AND D'ATTILIO, A., 1976. Murex *shells of the world. An illustrated guide to the Muricidae*. Stanford University Press, Stanford. 284 pp.

VOKES, E. H., 1978. Muricidae (Mollusca: Gastropoda) from the eastern coast of Africa. *Annals of the Natal Museum*, 23 (2): 375-418.

VOKES, E. H., 1985. Those amazing Mactan muricids (and some of their friends). *Conchologists of America Bulletin*, 13 (2): 29-34.

© Sociedad Española de Malacología —————— *Iberus*, 21 (2): 99-107, 2003

A new species of Phyllomeniidae (Mollusca Solenogastres: Sterrofustia) from the South Shetland Islands, Antarctica

Una nueva especie de Phyllomeniidae (Mollusca Solenogastres: Sterrofustia) de las Islas shetland del sur, antártida

Óscar GARCÍA-ÁLVAREZ* and Victoriano URGORRI*

Recibido el 14-XI-2002. Aceptado el 6-VI-2003

ABSTRACT

Ocheyoherpia bursata is a new species of Phyllomeniidae (Mollusca Solenogastres: Sterrofustia) collected at a depth of 248 m, on a gravel bottom off Deception Island (South Shetland Islands, Antarctica). The radula is distich, formed by pairs of hooked teeth (up to 48 µm long x 11 µm wide), each tooth with 5-6 lateral short denticles and a pair of long, curved and fused distal denticles, these distal denticles are located in the same plane as the radular tooth. Midgat with a pair of ventrolateral sacs posteriorly, which run ventraly under the spawning duct. The new species is compared with other two species of the genus. An amended diagnosis of the genus *Ocheyoherpia* is proposed.

RESUMEN

Ocheyoherpia bursata es una nueva especie de Phyllomeniidae (Mollusca, Solenogastres: Sterrofustia) recogida a 248 m de profundidad en un fondo de gravas en la Isla Decepción (Islas Sethland del Sur, Antártida). Rádula dística formada por pares de dientes ganchudos (hasta 48 µm de largo x 11 µm de ancho), cada diente con 5-6 dentículos laterales cortos y con un par de dentículos distales curvados y fusionados en su extremo distal, estos dentículos distales están situados en el mismo plano que el diente radular. El intestino medio presenta posteriormente un par de bolsas ventrolaterales situadas ventralmente al conducto de desove. La nueva especie se compara con las otras dos del género. Se propone una enmienda a la diagnosis del género *Ocheyoherpia*.

KEY WORDS: *Ocheyoherpia bursata*, Solenogastres, South Shetland Islands, Antarctica.
PALABRAS CLAVE: *Ocheyoherpia bursata*, Solenogastros, Islas Shetland del Sur, Antártida.

INTRODUCTION

During a sampling programme under the BENTART'95 project, a specimen was collected off Deception Island (South Shetland Island, Antarctica) that proved to belong to a new species of Solenogatres. Under the current classification, the Solenogastres are grouped into four orders based on the type of the mantle sclerites. The mantle, in the orders Pholidoskepia Salvini-Plawen, 1978, and Neomeniamorpha Pelseneer, 1906, has scales, whereas in the orders

* Departamento de Bioloxía Animal, Facultade de Bioloxía, Universidade de Santiago de Compostela, E-15782 Santiago de Compostela. España. E-mail: baoscar@usc.es; bavituco@usc.es

Sterrofustia Salvini-Plawen, 1978, and Cavibelonia Salvini-Plawen, 1978, mostly acicular sclerites are found. The order Sterrofustia, to which the species described here belongs, is characterized by solid acicular sclerites unlike in the order Cavibelonia where the acicular sclerites are hollow. The order Sterrofustia comprises nine species, grouped into three families with seven genera. As in all the families of the class Solenogastres, the three families belonging to the order Sterrofustia are based on the combinations of two features: the radula type and the ventral foregut glandular organs. The family Phyllomeniidae Salvini-Plawen, 1978, to which this new species belongs, is characterized by a distich radula and subepithelial ventral foregut glandular organs (type A after SALVINI-PLAWEN, 1978) in ampoule-shaped, whereas the other two familiaes have epithelial ventral foregut glandular organs (type B after SALVINI-PLAWEN, 1978).

MATERIAL AND METHODS

One specimen was collected during the Spanish campaign (BENTART'95) to study the Antarctic benthos at 248 m depth, at station R-22, to the south of Deception Island (South Shetland Islands, Antarctica), using a rock dredge on a gravel bottom. The specimen was fixed and preserved in 70% alcohol. The sclerites were studied by separation of small pieces of cuticle from the central dorsal area of the body and from the ventral groove. These pieces were treated with 5% sodium hypochloride for 12 h in order to isolate the sclerites. The sclerites were later rinsed with distilled water, dried under a heater at 40ºC and mounted with synthetic resin. For the anatomical study, the specimen was decalcified in ethylenediaminetetracetic acid (EDTA) solution for 12 h, cut in paraffin in a series of 10 μm cross-sections. The staining method used was Azan (after Heidenhain) and the anatomy was reconstructed from the serial cross-sections.

RESULTS

Order STERROFUSTIA Salvini-Plawen, 1978
Family PHYLLOMENIIDAE Salvini-Plawen, 1978

Ocheyoherpia Salvini-Plawen, 1978

Type species: *Ocheyoherpia lituifera* Salvini-Plawen, 1978

Amended diagnosis: Cuticle thik or thin with solid, acicular and hooked sclerites. Mouth opening in the atrium, directly or via a posterior channel without sclerites. Radula distich, teeth with a pair of curved and fused distal denticles. Midgut with diverticula. Without dorso-terminal sense organ. Unpaired genital orifice. With copulatory spicules and associated gland. Without respitatory folds.

Ocheyoherpia bursata new species

Type: The holotype (cut in serial sections) is deposited in the Museo Nacional de Ciencias Naturales of Madrid, number MNCN 15.02/10.
Type locality: Deception Island (station R-22-BENTART'95) South Shetland Islands, Antarctica (63° 03′ 26″ S; 60° 39′ 26″ W) 248 m depth.
Derivatio nominis: The specific name, *bursata*, refers to the midgut sacs observed in the posterior part of the animal.

Diagnosis: Body measues 2.25 mm x 0.55 mm. Moderately thick cuticle without keel, carina or protuberances. Two types of solid oar-shaped scales,

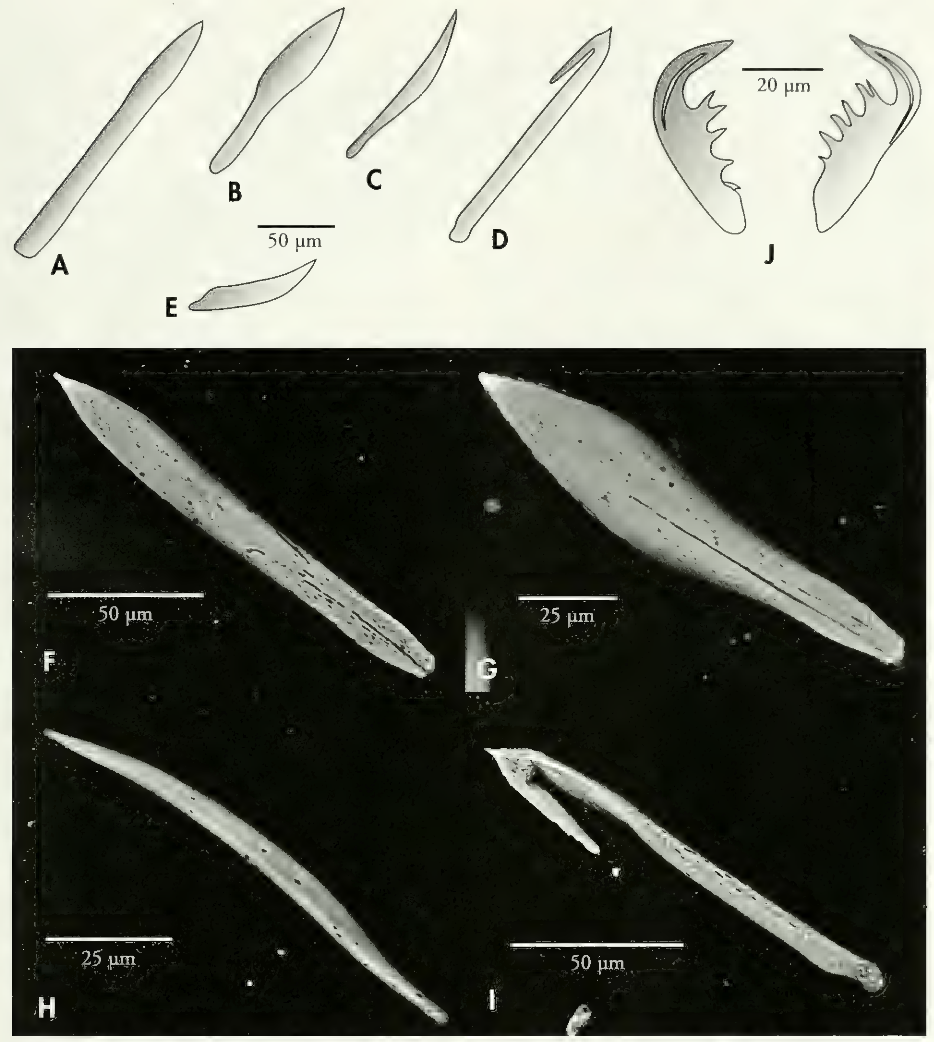


Figure 1. Mantle sclerites, and radular teeth of *Ocheyoherpia bursata* n. sp. A, F: long oar-shaped scale; B, G: short and wide oar-shaped scale; C, H: blade-shaped acicular sclerite; D, I: Hooked sclerite; E: blade-shaped scale from along the pedall groove; J: radular teeth

Figura 1. Escleritos del manto y diente radular de Ocheyoherpia bursata *n. sp. A, F: escama larga en forma de remo; B, G: escama corta y ancha en forma de remo; C, H: esclerito acicular en forma de hoja de cuchillo; D, I: esclerito ganchudo; E: escama en forma de hoja de chuchillo del surco pedio; J: diente radular.*

solid blade-shaped acicular sclerites and solid hooked sclerites. Mouth opens directly in the atrium. Pedal groove with a fold that does not enter the pallial cavity. Radula distich, teeth with 5-6 lateral denticles and one pair of curved and fused distal denticles. Midgut with pair of dorso-rostral caeca and posterior pair of ventro-lateral sacs. Paired seminal vesicles. With paired seminal receptacles. Three pairs of copulatory spicules.

Description

General morphology: The specimen measures 2.25 mm in length x 0.55 mm

in width. The ends of the body are rounded. The pedal groove is clearly visible, with a single ciliate fold that does not enter the pallial cavity.

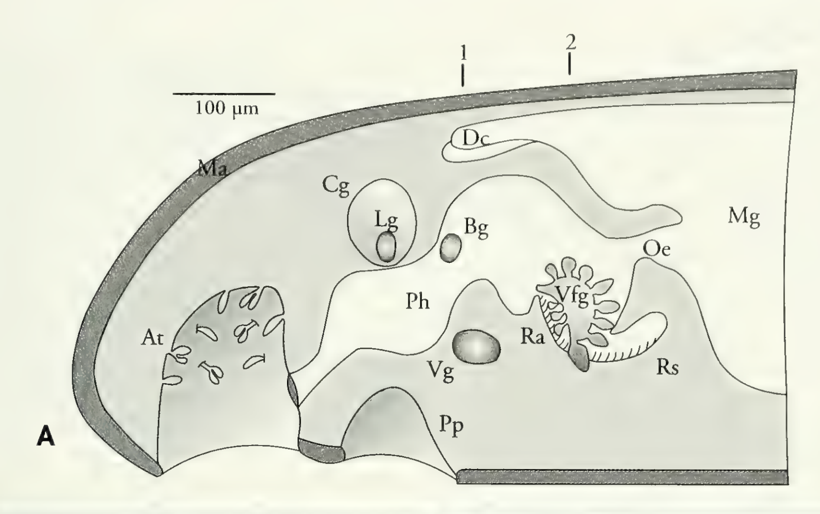
Mantle: The cuticle is moderately thick (30 to 35 µm), with epithelial papillae at the base and 2-3 layers of sclerites. There are two types of solid scales: long oar-shaped scales (up to 192 µm x 19 µm) (Fig. 1A, F) and short and wide oar-shaped scales (up to 138 µm x 213 µm) (Fig. 1B, G). And there are two types of solid sclerites: blade-shaped acicular sclerites (up to 119 µm x 12.5 µm) (Fig. 1C, H) and hooked sclerites with a sharp point at the top of the hook (up to 173 µm x 12 µm) (Fig. 1D, I). Blade-shaped scales occur along the pedal groove (up to 90 µm x 14.5 µm) (Fig. 1E).

Pallial cavity: The pallial cavity is small and lacks respiratory folds and connects to the exterior through a narrow ventro-terminal opening (Fig. 3A). The anus is narrow and opens into the cavity dorsally. The unpaired genital aperture is located in he dorso-frontal wall of the pallial cavity.

Sense organs and nervous system: The atrio-buccal cavity connects to the exterior through a small opening. The lateral and dorsal walls of the atrium have a great number of individual and bifurcated papillae. There is no dorso-terminal sense organ. The cerebral ganglion is voluminous (150 µm in width x 65 µm in length), and is located dorsal to the pharynx (Fig. 2A). The lateral ganglia are small (40 µm x 20 µm) and are situated on either sides of the cerebral ganglion. Two ventral ganglia (40-45 µm in diameter) are located latero-ventral to the pharynx, and are found on the posterior area of the pedal pit. A pair of buccal ganglia (20 µm in diameter) are located latero-dorsally to the pharynx. No suprarectal commissure was located.

Digestive tract: The mouth opens into the posterior area of the atrium (Fig. 2A). The buccal opening leads to a long pharynx with thickened walls and dorsal pharyngeal glands in its front part. The radula is distich, formed by pairs of hooked teeth (up to 48 µm long x 11 µm wide). Each tooth has 5-6 lateral short denticles and a pair of long, curved and fused distal denticles, the distal denticles being located in the same plane as the radular tooth (Fig. 1J, 2C). The pharynx opens to a short oesophagus, which leads to the midgut. There is a long radular sac (60 µm long), ventral to the oesophagus. A pair of subepithelial ventral foregut glandular organs (type A after SALVINI-PLAWEN, 1978) are ampoule-shaped and open laterally into the pharynx on either side of the beginning of the radula (Fig. 2A, C). The midgut has thick, glandular walls with lateral constrictions due to the dorso-ventral musculature. There is a very wide dorso-rostral caecum which frontally splits into two pouches (Fig. 2A, B). The posterior part of the midgut is narrow. It is extended postero-laterally by in a pair of sacs (similar to those described by HANDL (2002) in the posterior body of *Imeroherpia laubieri*), These run ventral to the spawning duct (Fig. 3A, C-E). Their dorsal walls have a glandular appearance similar to that observed in the midgut. The rectum is narrow and opens dorsally into the pallial cavity.

Reproductive system: The gonads were full of sperm and eggs. A pair of large sperm fulled seminal vesicles lead laterally into the gonopericardialducts, which also contain sperm (Fig. 3A, B). The pericardium is voluminous and also contains sperm. The heart is located in the dorsal wall of the pericardium. Two short pericardialducts lead from the posterior part of the pericardium, which curve and turn towards the anterior part of the pericardium, and then laterally to lead into the mid part of the spawning duct, when this is still unpaired (Fig. 3A, E). The spawning duct is short (225 µm long), its front half is paired, its posterior half is unpaired, wide and dorsoventrally flattened. It opens dorso-rostrally into the pallial cavity through an unpaired genital pore. There are two small seminal receptacles, which lead into the dorso-rostral part of each spawning duct (Fig. 3A, C). There are three pairs of copulatory spicules and one



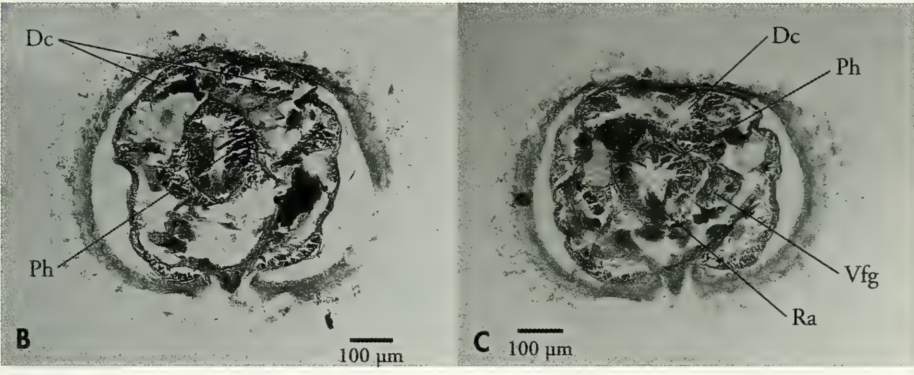


Figure 2. A: Schematic organization of the anterior part of the body of *Ocheyoherpia bursata* n. sp. B, C: Microphotographs of the cross-sections of the anterior region of the body corresponding to lines 1, 2. At: Atrial sense organ; Bg: Buccal ganglion; Cg: Cerebral ganglion; Dc: Dorsal caecum; Lg: Lateral ganglion; Ma: Mantle; Mg: Midgut; Oe: Oesophagus; Ph: Pharynx; Pp: Pedal pit; Ra: Radula; Rs: Radular sac; Vfg: Ventral foregut glandular organ; Vg: Ventral ganglion.

Figure 2. A. Organización esquemática de la parte anterior del cuerpo de Ocheyoherpia bursata n. sp. B, C. Microfotografías de los cortes en sección de la región anterior del cuerpo correspondientes a las líneas 1, 2. At: Órgano sensitivo atrial; Bg: Ganglio bucal; Cg: Ganglio cerebral; Dc: Ciego dorsal; Lg: Ganglio lateral; Ma: Manto; Mg: Intestino; Oe: Esófago; Ph: Faringe; Pp: Foseta pedia; Ra: Rádula; Rs: Saco radular; Vfg: Órgano glandular ventral de la faringe; Vg: Ganglio ventral.

pair of associated glands (Fig. 3A, D). The copulatory spicules comprise two groups of three located ventro-laterally, each group includes a long spicule (approximately 475 µm), a second shorter spicule (approximately 295 µm), located distally from the first, both extending to the pallial cavity and a third short spicule (approximately 100 µm) located in the area where the copulatory gland narrows and terminates. The two copulatory glands are long (approximately 430 µm) and tubular (Fig. 3A, B), the glandular walls are very similar in appearance to the walls of the spawning duct. Anteriorly copulatory glands are wide (105 µm in diameter), posteriorly these glands narrow in a duct which appears to open on the posterior third of the longest copulatory spicule (Fig. 3A).

DISCUSSION

Ocheyoherpia bursata n. sp. is placed in the order Sterrofustia, because the sclerites mantle are formed mostly by solid acicles. The distich radula and the subepithelial ventral foregut glandular organs (type A after SALVINI-PLAWEN, 1978) in ampoule-shaped, would place this species within the family Phyllomeniidae. SCHELTEMA (1999) however, differs and does not include the genus *Ocheyoherpia* in the family Phyllomeniidae because it does not have true gonoducts which she holds as being unique to true species of genus *Phyllomenia*. Furthermore the skeletal sclerites are lacking in *Ocheyoherpia* spp; and the radular teeth have the form of a bar with denticles, unlike the distichous hooks of the Phyllomeniidae. Nevertheless we think, as SALVINI-PLAWEN (1978, 2003), that the presence of true gonoducts could represent a specialisation within that genus. The sclerites mantle are mostly formed by solid acicles like genus *Phyllomenia* and *O. bursata* n. sp. has two types of oar-shaped scales similar to those described in species of the genera *Phyllomenia* Thiele, 1913, and *Lituiherpia* Salvini-Plawen, 1978 (SALVINI-PLAWEN, 1978). And the type of radula presented by the genus *Ocheyoherpia*, see Figure 1J here, Figure 93 (SALVINI-PLAWEN, 1978) in the original descriptions of *Ocheyoherpia lituifera* Salvini-Plawen, 1978 and Figure 4 (SCHELTEMA, 1999) in the original descriptions of *Ocheyoherpia trachia* Scheltema, 1999, show that they have radulae formed by pairs of hooked teeth with smaller lateral denticles, i.e., distich radulae, like those of the Phyllomeniidae and not bar-shaped radular teeth with denticles.

O. bursata n. sp., has characters diagnostic of the genus in the sense of SALVINI-PLAWEN (1978) and SCHELTEMA (1999). Some characters, however, are particular to this new species and do not correspond with those of the other two species of the genus (*O. lituifera* and *O. trachia*) and lead us to specify the diagnosis of the genus. In the original diagnosis of the genus (SALVINI-PLAWEN, 1978), it is reported that types of sclerites: solid acicles and hooks are present. SCHELTEMA (1999) extends this diagnosis by adding a third type: solid serrated acicular sclerites at the distal tip, since they appear in two species known at this time; but in our observations, the new species *O. bursata* has no acicular sclerites with a serrated distal tip. We believe that the original diagnosis of the genus should prevail, i.e. there are two types of solid sclerites: acicles and hooked. In the diagnosis of the genus, SALVINI-PLAWEN (1978) states that the mouth opens in a channel with no sclerites and which is linked to the atrium, i.e., the mouth is actually in the atrium, since the channel is a continuation of the atrium, as deduced from the description and illustration. In *O. bursata* n. sp., we note that the mouth is clearly in the posterior part of the atrium; for this reason, in the generic diagnosis, should indicate that the mouth opens into the atrium, directly or via a posterior channel without sclerites. The radula in the genus *Ocheyoherpia* is distich, as per the original diagnosis (SALVINI-PLAWEN, 1978). Our observations coincide with those of SCHELTEMA (1999) in that the radular teeth present a pair of characteristic curved and fused distal denticles, a character which should be added to the diagnosis of the genus. In *O. bursata* n. sp., the distal denticles are located in the same plane as the rest of the radular tooth and are not curved upwards and back, as described by SCHELTEMA (1999) in *O. trachia*, so that this latter characteristic should not be included in the diagnosis. Consequently, we include an amended diagnosis of the genus *Ocheyoherpia* in the Results section.

Before this study two species of the genus *Ocheyoherpia* were known, both from Antarctic or sub-Antarctic waters (SALVINI-PLAWEN, 1978; SCHELTEMA, 1999): *O. lituifera* Salvini-Plawen, 1978 is known of the South Sandwich Islands, South Georgia and the South Shetland Islands; and *O. trachia* Scheltema, 1999 is known of the Macquarie Island.

There are clear differences (Table I) between *O. bursata* n. sp. and the other two species of the genus (SALVINI-PLAWEN, 1978; SCHELTEMA, 1999). *O. bursata*

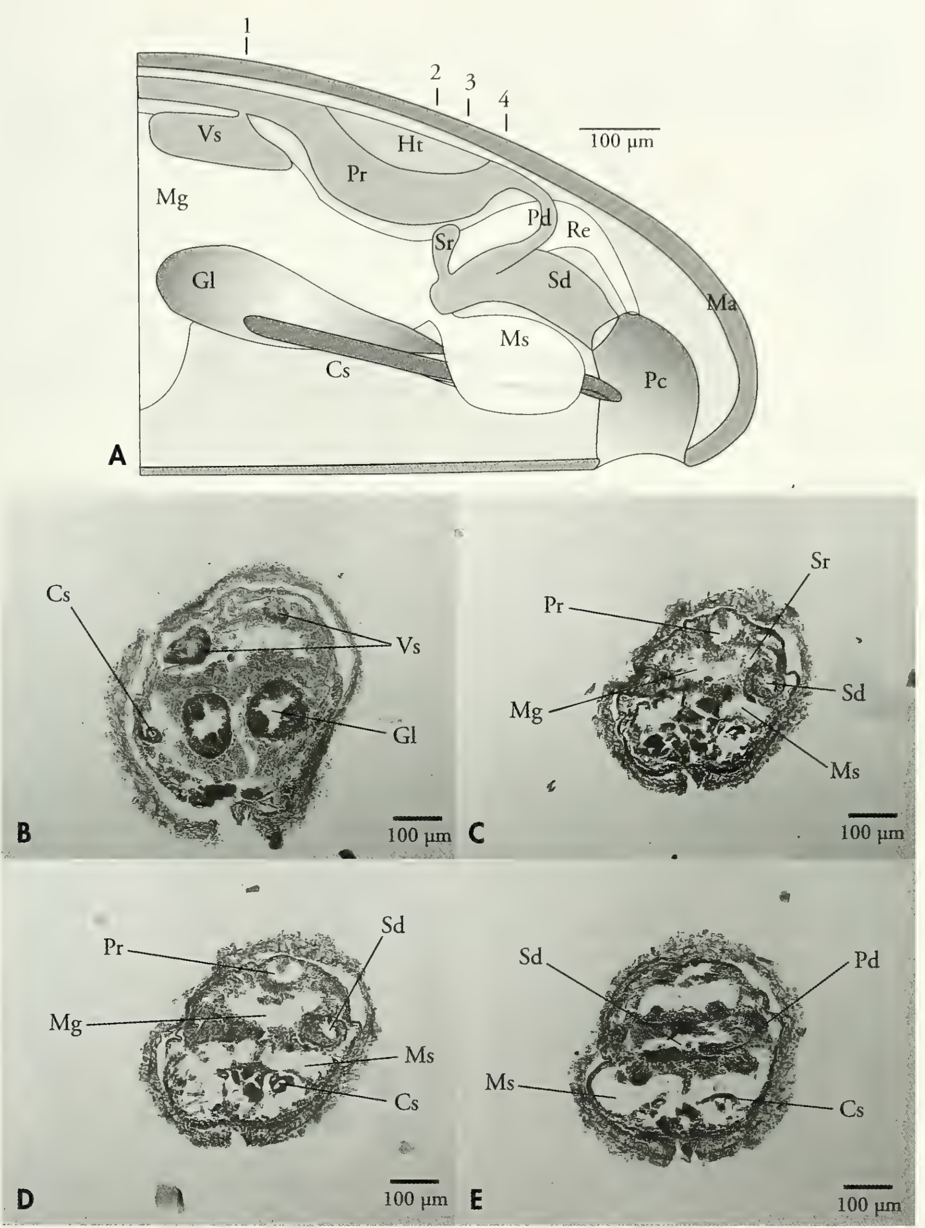


Figure 3. A: Schematic organization of the posterior part of the body of *Ocheyoherpia bursata* n. sp. B, C, D, E: Microphotographs of the cross-sections of the posterior region of the body corresponding to lines 1, 2, 3, 4. Cs: Copulatory spicule; Gl: Copulatory gland; Ht: Heart; Ma: Mantle; Mg: Midgut; Ms: Midgut sac; Pc: Pallial cavity; Pd: Pericardioduct; Pr: Pericardium; Re: Rectum; Sd: Spawning duct; Sr: Seminal receptacle; Vs: Seminal vesicle.

Figure 3. A: Organización esquemática de la parte posterior del cuerpo de Ocheyoherpia bursata n. sp. B, C, D, E: Microfotografías de los cortes en sección de la región posterior del cuerpo correspondientes a las líneas 1, 2, 3, 4. Cs: Espículas copulatrices; Gl: Gládula copulatríz; Ht: Corazón; Ma: Manto; Mg: Intestino; Ms: Saco del intestino; Pc: Cavidad paleal; Pd: Pericardioducto; Pr: Pericardio; Re: Recto; Sd: Conducto de desove; Sr: Receptáculo seminal; Vs: Vesícula seminal.

Table I. Comparative table of characters for *Ocheyoherpia* species.
Tabla I. Tabla comparativa de los caracteres de las especies de Ocheyoherpia.

	O. lituifera	*O. trachia*	*O. bursata* n. sp.
Size	5 x 0.5 mm	6.5 x 1.4 mm	2.25 x 0.55 mm
Carina	No	Yes	No
Cuticula	35-60 µm	18-22 µm	30-35 µm
Serrated acicles	Yes	Yes	No
Oar-shaped scales	No	No	Yes
Buccal opening	In atrial channel	---	In atrium
Radular teeth	64 x 10 µm	75 x 18 µm	48 x 11 µm
	Distal denticles upwards and back. 5-6 lateral denticles	Distal denticles upwards and back. 7-9 lateral denticles	Distal denticle in same plane as radular tooth. 5-6 lateral teeth
Posterior midgut sacs	No	No	Yes
Seminal vesicles	No	Yes	Yes
Copulatory glands	Into a triangular tube formed by 3 small copulatory spicules	Open into the grooved distal end of smaller copulatory spicule	Open in the posterior third part of longest copulatory spicule
Copulatory spicules	4 pairs, 3 small, 1 large	2 pairs, 2 different sizes	3 pairs, 3 different sizes

n. sp. has a pair of midgut sacs extending under the spawning duct, which are not present in *O. lituifera* and *O. trachia*. As regards the mantle sclerites, *O. lituifera* and *O. trachia* have distally serrate acicular sclerites which *O. bursata* n. sp. lacks, nevertheless, *O. bursata* n. sp. has two types of oar-shaped scales which are not present in the other two species. The radula in *O. bursata* n. sp. is smaller (48 µm long in *O bursata* n. sp. by 64 µm long in *O. lituifera* and 75 µm long in *O. trachia*). It also has the pair of fused distal denticles in the same plane as the radular tooth, this clearly differs from the arrangement of the fused distal denticles in *O. lituifera* and *O. trachia* (SCHELTEMA, 1999), where the denticles curve upwards and back and lie in a different plane to that of their base (see Figs . 4D, F and 5B in SCHELTEMA, 1999). The copulatory glands in *O. bursata* n. sp. open on the posterior third part of the longest compulatory spicule, however in *O. lituifera* it opens into a triangular tube formed by the tree small copulatory spiculaes and in *O. trachia* it opens into the grooved and ridged distal end of the smaller copulatory spicule. *O. bursata* n. sp. further differs (Table I) from each of the other two species in the genus (SALVINI-PLAWEN, 1978; SCHELTEMA, 1999): *O. bursata* n. sp. differs from *O. lituifera* in that it has a thin cuticle (30-35 µm in *O. bursata* n. sp. and 35-60 µm in *O. lituifera*) and differs from *O. trachia* in that the cuticle is thicker (30-35 µm as compared wich 18-22 µm). *O. trachia* has a carina which is not present in *O. bursata* n. sp. *O. bursata* n. sp. has well developed seminal vesicles, which are not described for *O. lituifera*. *O. bursata* n. sp. has 3 pairs of copulatory spicules but only 2 pairs are described for *O. trachia* and 4 pairs for *O. lituifera*

ACKNOWLEDGEMENTS

We are grateful to Prof. Dr. Fernando Cobo Gradín at the University of Santiago de Compostela and to Prof. Dr. Luitfried v. Salvini-Plawen at the University of Vienna for their invaluable help. This paper is part of the BENTART research projects (ANT94-1161-E, ANT95-1011; ANT97-2097-E) and the Integrated Spanish-Austrian Co-operation Actions (HU1997-0002; HU2000-0010). Our thanks also to Ian Emmett for the English translation.

BIBLIOGRAPHY

Handl, C.H. 2002. *Imeroherpia laubieri*, a new Solenogaster from the Bay of Biscay. *Journal of Molluscan Studies*, 68: 329-335..

Salvini-Plawen, L .V. 1978. Antarktische und subantarktische Solenogastres. Eine Monographie: 1898-1974. *Zoologica* (Stuttgart), 128: 1-315.

Scheltema, A. H. 1999. Two Solenogaster Molluscs, *Ocheyoherpia trachia* n.sp. from Macquarie Island and *Tegulaherpia tasmanica* Salvini-Plawen from Bass Strait (Aplacophora: Neomeniomorpha). *Records of the Australian Museum*, 51: 23-31.

Salvini-Plawen, L .V. 2003. On the phylogenetic significance of the aplacophoran Mollusca. *Iberus*, 21 (1): 67-97.

© Sociedad Española de Malacología ——————— Iberus, 21 (2): 109-122, 2003

Foregut and reproductive tract anatomy of three species of the *Strombina*-group (Buccinoidea: Columbellidae)

Anatomía del tubo digestivo y del tracto reproductor en tres especies del grupo Strombina (Buccinoidea: Columbellidae)

Helena FORTUNATO*

Recibido el 13-IX-2002. Aceptado el 16-VI-2003

ABSTRACT

This paper reports for the first time anatomical data for three species of the *Strombina*-group sensu Jung, 1989: *Bifurcium bicanaliferum, Sincola (Dorsina) gibberula* and *Clavistrombina clavulus*. Anatomical data for the foregut and reproductive tracts were determined from gross dissections mainly of living specimens. Both the anterior digestive tract and the reproductive systems of the three species are similar in their general plan and conform with what is known for columbellids and neogastropods in general.

Differences among the three species are mostly within accessory structures. None of them presents either a bursa copulatrix or a prostate gland. The ingestive gland is also absent. *C. clavulus* males present an open reproductive system with a diverticulum communicating the vas deferens with the body cavity. This species also presents a separated albumen gland, whereas in both *S. gibberula* and *B. bicanaliferum* only an internal septum separates this gland from the capsule gland. *Bifurcium* and *Sincola* both appear during the early Miocene of Dominican Republic, which could bear on their anatomical similitude, whereas *Clavistrombina* is a Recent genus of the eastern Pacific. More studies of other species of these genera are needed in order to better understand possible evolutionary connections of these body plans.

RESUMEN

Se describe por vez primera datos anatómicos de tres especies del grupo *Strombina* sensu Jung, 1989: *Bifurcium bicanaliferum, Sincola (Dorsina) gibberula* y *Clavistrombina clavulus*. Los datos anatómicos se determinaron a partir de disección de especimenes vivos. Los tractos digestivo y reproductor de las tres especies estudiadas son similares en su estructura general y se corresponden con los conocidos para columbellidos y neogasterópodos en general.

Las diferencias se concentran en las estructuras accesorias. Ninguna especie presenta bolsa copulatriz, próstata o glándula ingestiva. Los machos de *C. clavulus* tienen un sistema reproductor abierto con un divertículo que comunica el vaso deferente con la cavidad del cuerpo. Esta especie tiene una glándula del albumen separada, mientras que en *S. gibberula* y en *B. bicanaliferum* sólo un septo la separa de la de la cápsula. Tanto *Bifurcium* como *Sincola* aparecieron durante el Mioceno temprano en la República Dominicana, lo cual puede explicar su similitud anatómica, mientras que *Clavistrombina* es una especie reciente del Pacífico este. Se precisan más estudios sobre otras especies de estos géneros para una mejor comprensión de las posibles conexiones evolutivas entre estas características anatómicas.

KEY WORDS: Gastropods, Strombina-group, anatomy, foregut, reproductive tract
PALABRAS CLAVE: Gasterópodos, grupo Strombina, anatomía, tracto digestivo, tracto reproductor.

* Center for Tropical Anthropology and Paleoecology, Smithsonian Tropical Research Institute, P.O. Box 169, Balboa, Panama R P, e-mail: fortunae@ancon.si.edu

INTRODUCTION

Neogastropods are generally considered the most highly evolved prosobranch gastropods. This large order, with more than 1000 recent and fossil genera and subgenera (TAYLOR AND SOHL, 1962), is characterized by a shell with an elongate siphonal canal and rachiglossate or toxoglossate radula. The classification and biology of neogastropods has been the focus of many authors as it contains several extremely important groups, both economically and biologically (ADAMS AND ADAMS, 1858; THIELE, 1929; RISBEC, 1954; FRETTER AND GRAHAM, 1962; PONDER, 1973; HARASEWYCH, 1984; BRIGHT AND ELLIS, 1990; KOOL, 1993).

Neogastropods have a rather similar anatomical organization. This was shown to be true for the reproductive systems of the Muricidae, Buccinidae, and Nassaridae (FRETTER, 1941; FRETTER AND GRAHAM, 1962). Families such as Olividae, Columbellidae, Fasciolaridae and Turridae are less studied (MARCUS AND MARCUS, 1959, 1960, 1962; SMITH, 1967; HOUSTON, 1976; KANTOR, 1991; SYSOEV, 1991). The foregut of some of these groups shows signs of simplification, as in the Muricidae (GRAHAM, 1949), whereas others have features of the Archaeogastropoda (BROWN, 1969; PONDER, 1972), or have become secondarily complex (PONDER, 1970).

The family Columbellidae, one of the groups traditionally included in the buccinoid neogastropods, appears during the Eocene (RADWIN, 1977a). Although relatively younger than most other neogastropod taxa, which appear in the Cretaceous, is one of the most diverse and abundant, with almost four hundred recent species (TAYLOR, MORRIS AND TAYLOR, 1980). Contrasting with this, there aren't that many works dealing with the anatomy of this group, as stated above. THIELE (1929) and RADWIN (1977a, 1977b) use radular features to subdivide the family into two subfamilies. RISBEC (1954) and especially MARCUS AND MARCUS (1962, 1964) give the first anatomical descriptions of several columbellid species. Later, HOUSTON (1976) and HOUSTON AND HATFIELD (1981) described a couple more species. Several other species were studied in relation to evolution of herbivory in gastropods (HATFIELD,1979; HARASEWYCH, 1990; KANTOR AND MEDINSKAYA, 1991; MEDINSKAYA, 1992; MEDISNKAYA, 1993; GURALNICK AND DE MAINTENON, 1997; DE MAINTENON, 1999).

The Panamic province has a rich assemblage of columbellids many of which have a very interesting evolutionary history related to the rise of the Central American Isthmus . This is the case with the *Strombina*-group sensu Jung, 1989. The group consists of five genera and includes most taxa classified as *Strombina* by earlier workers. JUNG (1989) splits this genus and proposes several new genera. Despite the splitting, the group is still known in the malacological jargon as the *Strombina*-group, following JUNG's (1989) designation. The group needs extensive systematic revision (DE MAINTENON, 1994) and the relations of these genera to other tropical American columbellids and to each other is still poorly unknown (RADWIN, 1977a, 1977b; JUNG, 1989). Nevertheless, preliminary cladistic analyses based on shell morphology and anatomy strongly support the hypothesis of a separate columbellid clade composed by these five genera, as well as the validity of JUNG'S (1989) major genera and subgenera (FORTUNATO AND JUNG, 1995).

The *Strombina*-group is amongst the most abundant and diverse Neogene gastropods, and is represented by more than 30 living species in the eastern Pacific but only four in the Caribbean, where they suffered a massive extinction at the end of the Pliocene (JUNG, 1989; JACKSON, JUNG, COATES AND COLLINS, 1993; JACKSON, JUNG AND FORTUNATO, 1996; FORTUNATO, 1999).

The *Strombina*-group has been used as a model taxon to study changing species morphology and diversity during the gradual emergence of the Isth-

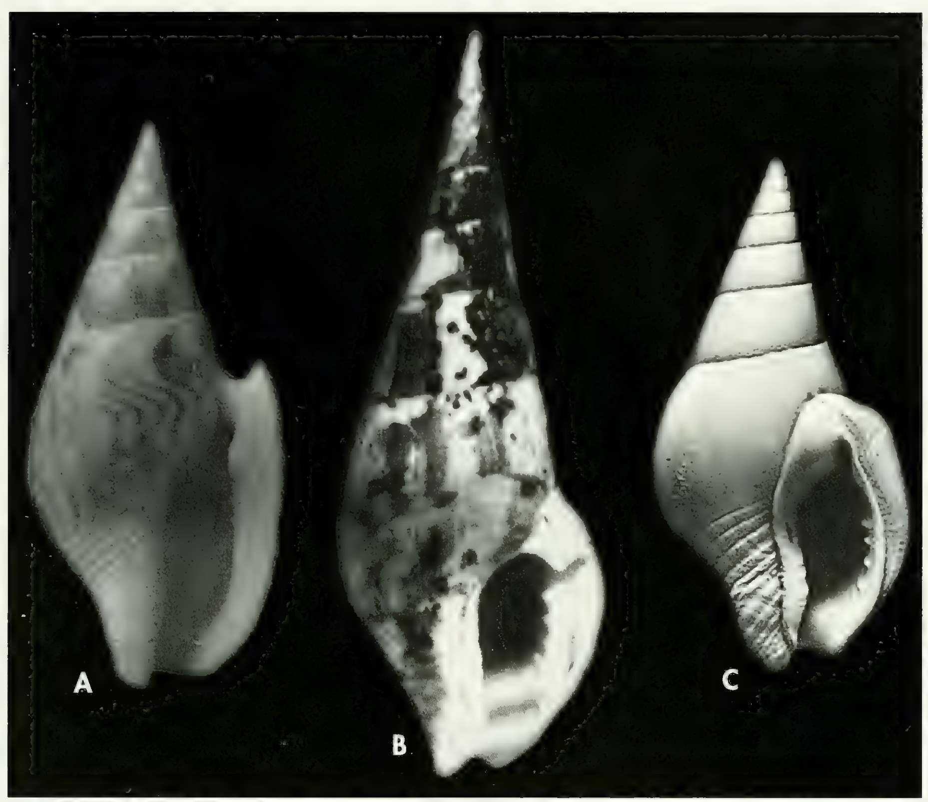


Figure 1. Portraits of the species studied. A: *Bifurcium bicanaliferum* (B. G. Sowerby I, 1832); B: *Sincola (Dorsina) gibberula* (B. G. Sowerby I, 1832); C: *Clavistrombina clavulus* (B. G. Sowerby I, 1834).
Figura 1. Especies estudiadas. A: Bifurcium bicanaliferum *(B. G. Sowerby I, 1832); B:* Sincola (Dorsina) gibberula *(B. G. Sowerby I, 1832); C:* Clavistrombina clavulus *(B. G. Sowerby I, 1834).*

mus of Panama (JACKSON, JUNG AND FORTUNATO, 1996; FORTUNATO, 1998, 1999). In spite of this, very little is known of the biology of these gastropods (CIPRIANI AND PENCHASZADEH, 1993; CIPRIANI, FORTUNATO AND RODRIGUEZ, 1996; FORTUNATO, PENCHASZADEH AND MILOSLAVICH, 1998; FORTUNATO, 2002). There are no anatomical studies of any of its species, except for some references to the type of radulae (RADWIN, 1978; HOUBRICK, 1983; EMERSON, 1993). The objective of this paper it is to present the gross anatomy of the digestive and reproductive systems of three species: *Bifurcium bicanaliferum* (G. B. Sowerby I, 1832), *Sincola (Dorsina) gibberula* (G. B. Sowerby I, 1832) and *Clavistrombina clavulus* (G. B. Sowerby I, 1834). *B. bicanaliferum* is the only living species of this genus otherwise known from Miocene deposits of the Caribbean. *S. gibberula* is one of the three extant species of this genus, also known from Miocene deposits of the Caribbean. *C. clavulus* is the only species of this monotypic genus and has no known fossil record (JUNG, 1989). All three species inhabit the shallow water (up to 40 m deep) coasts of the eastern Pacific. Whereas the first two species can be found in muddy and sandy beaches, the third prefers rocky environments. In spite of the fact that all three species have a very wide distribution, ranging from the Gulf of California

Table I. Summary of dimensions of several organs for the three species discussed here. Measurements were made with fixed specimens using light microscopy.
Tabla I. Resumen de las dimensiones de varios órganos de las tres especies estudiadas. Las medidas fueron hechas a partir de especímenes fijados con un microscopio óptico.

			Radulae					Opercula	
Genus and species	Length of penis (mm)	Length of proboscis (mm)	Length (mm)	N. of lateral teeth	Size of lateral teeth (μm)	N. of medial plate	Size of medial plate (μm)	Length (mm)	Width (mm)
Bifurcium bicanaliferum	11	10	12	360	79	180	30	1.2	1
Sincola gibberula	7	5	15	450	53	225	20	1.5	1
Clavistrombina clavulus	12	7	10	418	68	209	26	4	2

through Peru, *C. clavulus* is much less abundant than the other two species. All three species are scavengers and have planktotrophic larvae (FORTUNATO *ET AL.*, 1998; FORTUNATO, 2002).

MATERIAL AND METHODS

All work was done with live collected specimens. Collections were done by hand during low tides and by trawling from small boats. Both live and preserved in 5% buffered formalin material was used for this study. About 10 specimens of both sexes from each studied species were dissected. Soft parts were removed from the shells with a vise after the animals have been relaxed with menthol crystals added to the seawater. Before dissecting, material was submerged in Methylene blue to delineate tissues and organs for gross anatomy study. Histological sections were done to study the proboscises. Standard histological techniques were used, the tissues infiltrated with paraffin and sectioned at 7 μm. Transverse sections of of the proboscis were stained with Hematoxylin/eosin (HUMASON, 1962). Measurements of penises, proboscises, and radular teeth were done in fixed specimens using light microscopy and a millimeter ocular . Radulae were removed and cleaned with warm 10% KOH until completely free of tissue. Opercula were treated with 37% hydrogen peroxyde. Both radulae and opercula were coated with gold-palladium, and examined under a JEOL HMS-5300LV Scanning Electron Microscope.

RESULTS

1. Morphology of the anterior alimentary tract

Bifurcium bicanaliferum (Fig. 1A)

The operculum (Fig. 2A) is yellowish, rounded, and small (1 mm long and 1.2 mm wide) (Table I). It is very thin and transparent with a proteinaceous consistency. The growth rings are evenly spaced and it has an antero-posterior located nucleus.

The animal has a long, very mobile proboscis (prb) tapering towards a small slit-like mouth opening (mo) (Fig. 4). When resting, the basal part of the proboscis retracts into a tubular fold of the body wall, the proboscis sheath. The proboscis measures about 10 mm (in a fixed animal) (Table I) and is of pleurembolic type, typical of a scavenger and predatory life style.

The mouth leeds to the buccal cavity which occupies the first portion of the

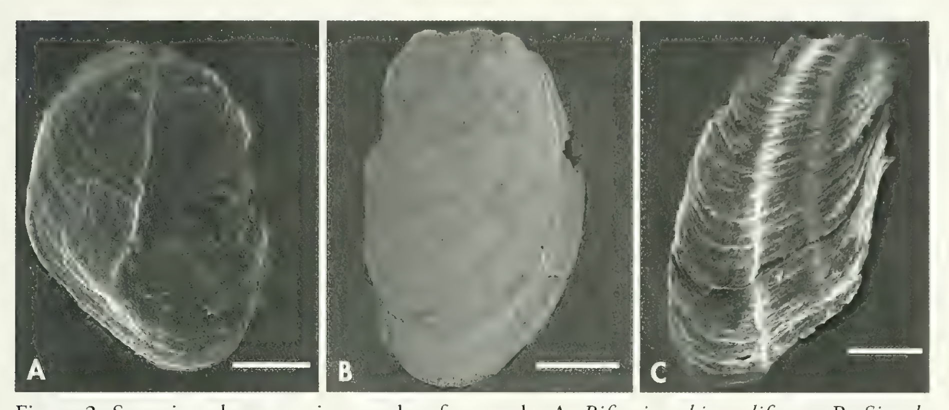


Figure 2. Scanning electron micrographs of opercula. A: *Bifurcium bicanaliferum*; B: *Sincola (Dorsina) gibberula*; C: *Clavistrombina clavulus*. Scale bar 50 µm.
Figura 2. Microfotografías al MEB de opérculos. A: Bifurcium bicanaliferum*; B:* Sincola (Dorsina) gibberula*; C:* Clavistrombina clavulus. *Escalas 50 µm.*

proboscis. Here the odontophore and the radular sac are located. The rachiglossate type radula (1+1+1) (Fig. 3A) is about 12 mm in length (Table I). The radular ribbon is typically collumbellid in shape, narrow, and has two lateral rows of 180 teeth. The median plate, or rachidian tooth, is almost rectangular, long and has rounded edges. Each median plate is 30 µm in length. The lateral teeth have a sigmoid shape and are separated from the rachidian by a large inter-space. Each lateral tooth measures 79 µm in length. They have a wide base, a shaft and two hooked cusps at the tip. A single blunt hook appears in the middle of the tooth shaft. The radula and several layers of the surbradular membrane together form the radular sheath at the end of which the radula is secreted.

The anterior oesophagus, (Fig. 4; aoe), starts at the posterior end of the buccal cavity after separating from the radular sac. Inside the proboscis, the anterior oesophagus has a ventral position. Once it leaves the proboscis, it continues towards the neural ring. This section of the oesophagus is adhered up to its middle through a connective tissue layer to the proboscis sheath. Just after the neural ring, the anterior oesophagus expands in diameter forming the Valve of Leiblein (vle) or oesophageal bulb. The valve has a reddish natural coloration and a pear shape. The oesophageal bulb is surrounded by the large salivary glands (sgl). These are paired, yellowish glands and they are not attached to the valve. These glands are lobed and the lobes are held together by strong strands of tissue. The salivary ducts (sd) leave the glands and enter the lateral walls of the anterior oesophagus just before the expansion that represents the oesophageal bulb. The ducts follow the anterior oesophagus and discharge their secretions in the buccal mass. The oesophageal bulb signals the beginning of the mid-oesophagus (moe). This bulbous expansion prevents the food from being sucked forward.

The beginning of the mid-oesophagus is narrow. After traversing the neural ring, it makes an S-shape curve after which it begins to engross. The large Gland of Leiblein (gle), or foregut gland, enters directly into the mid-oesophagus without a delimited duct. This unpaired gland has a V-shape and is dark brown. After the insertion of the foregut gland, the oesophagus continues to enlarge becoming the posterior oesophagus (poe) that ends in the stomach.

The proboscis is very long and its wall is composed of a thin outer layer of cuticle (cut) (Fig. 5). The cells here are cubic with a big central nucleus. The next layer is composed of longitudinal muscles (lml) followed by a layer of helical muscle tissue (hml). The subradular cartilages (sc), located within the radular sac (rs), have big cells with a central nucleus. The anterior oesophagus (aoe) is lined with a layer of columnar epithelium interspersed with mucous ciliated cells. The salivary ducts (sd) are located laterally relative to the anterior oesophagus.

Sincola (*Dorsina*) *gibberula* (Fig. 1B)

The operculum of this species (Fig. 2B) is very similar to the anterior one. It is oval shaped, small for the overall size of the animal (1mm long, 1.5 mm wide) (Table I), and yellowish. Its consistency is proteinaceous and it is somewhat thin and transparent. The growth rings are evenly spaced and it has an antero-lateral located nucleus.

Figure 6 shows a short (5 mm) pleurembolic type proboscis (prb) (Table I) that ends in a small slit-like mouth opening (mo). The proboscis in this species is almost translucent. Its basal part retracts into a tubular fold of the body wall, the proboscis sheath.

The mouth leeds to the buccal mass where the odontophore and the radular sac are located. The rachiglossate type radula (1+1+1) (Fig. 3B) is about 15 mm in length (Table I). The typically columbellid radular ribbon is narrow, and has two lateral rows of 225 teeth. The rachidian tooth is almost square in shape, narrow, with rounded edges. It measures 20 µm. The sigmoid lateral teeth are separated from the median plate by a large inter-space. Lateral teeth have a wide base and a shaft with two hooked cusps at the tip. Lateral teeth measure 53 µm. The hook in the middle of the tooth shaft is better delineated here than in the previous species. The radula is constantly being secreted at the end of the radular sheath, formed by the radula itself and the layers of the subradular membrane.

The anterior oesophagus (Fig. 6; aoe) begins at the posterior end of the buccal mass and runs dorsally inside the proboscis. The Valve of Leiblein (vle) or oesophageal bulb consists of a small expansion of the oesophagus just before the neural ring has a reddish natural coloration and a pear shape and is surrounded by the large salivary glands (sgl). These paired, creamy glands are not connected in any way to the valve. These glands are lobed and the lobes are held together by strong strands of tissue. The long and curved salivary ducts (sd) leave the glands and enter directly into the anterior oesophagus through the posterior lateral walls of the proboscis. The ducts run laterally inside the oesophagus and discharge their secretions into the buccal mass. The mid-oesophagus (moe) begins after the oesophageal bulb. The mid-oesophagus is thick in most of its length. The Gland of Leiblein (gle), or foregut gland, enters into the mid-oesophagus through a small, narrow duct. This is a small, light brown, unpaired organ, with a conic shape. The posterior oesophagus (poe), that starts after the insertion of the foregut gland, ends in the stomach.

The proboscis walls have an outer layer of cuticle (cut) (Fig. 7). The cells of the cuticle are big, cubic, and have a prominent central nucleus. The next layer is composed of helical muscles (hml) followed by a layer of longitudinal muscle tissue (lml).

The presence of abundant connective tissue (ct) is noticeable at this level. The subradular cartilages (sc), located within the radular sac (rs), have big cells with a prominent nucleus. Remnants of radular teeth can also be observed inside the radular sac. The salivary ducts (sd) are located on both sides of the anterior oesophagus (aoe). The later has an internal layer of columnar epithelium interspersed with mucous ciliated cells.

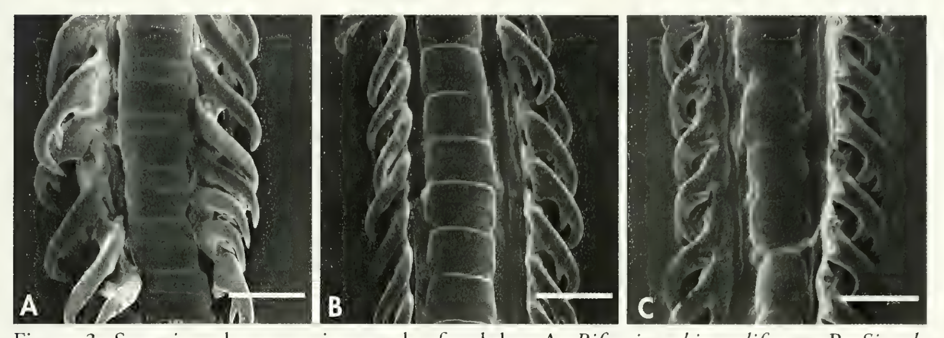


Figure 3. Scanning electron micrograph of radulae. A: *Bifurcium bicanaliferum*; B: *Sincola (Dorsina) gibberula*; C: *Clavistrombina clavulus*. Scale bar 100 µm.
Figura 3. Microfotografías al MENB de rádulas. A: Bifurcium bicanaliferum*; B:* Sincola (Dorsina) gibberula*; C:* Clavistrombina clavulus. *Escalas 100 µm.*

Clavistrombina clavulus (Fig. 1C)

The operculum (Fig. 2C) of this species is quite different from the two described before. It has a lenticular shape, brownish color, and is four millimeters long and two millimeters wide (Table I). It is relatively thick with a corneous consistency. The growth rings are evenly spaced and it has an antero-posterior located nucleus, and exhibits a ridge in the middle which gives it a very uncommon aspect.

Figure 8 shows a short proboscis (prb) that ends in a small slit-like mouth opening (mo). At rest, the basal part of the proboscis retracts into the proboscis sheath formed by a tubular fold of the body wall. The proboscis measures seven millimeters (in a fixed animal) (Table I) and is of pleurembolic type.

The mouth ends in the buccal mass located in the first section of the proboscis, and where the odontophore and the radular sac are located. The radula is 10 mm in length (Table I) and is rachiglossate (1+1+1) (Fig. 3C). The radular ribbon has a collumbellid shape, is narrow, and is composed of two lateral rows of 209 teeth. The median plate, or rachidian tooth, is almost square, with rounded edges. The median plate is 26 µm in length. The lateral teeth are sigmoid, and separated from the median plate by a very large inter-space. These teeth are 68 µm in length. The lateral tooth is composed of a narrow base, a shaft with a single hook in the middle, and two hooked cusps at the tip. The radular teeth are secreted at the end of the radular sheath. The later is formed by the radula itself and several layers of the surbradular membrana bundled together.

The short anterior oesophagus (Fig. 8; aoe) starts at the posterior end of the buccal cavity after separating from the radular sac. It runs laterally and expands into the oesophageal bulb or Valve of Leiblein (vle) shortly after leaving the proboscis. The valve is small, somewhat elongated, and translucent. The paired salivary glands (sgl) have a yellowish color and surround the oesophageal bulb. The lobes of the salivary glands are quite big. They are held together by connective tissue. The salivary ducts (sd) are long and curved. They leave the glands and enter the lateral walls of the proboscis, almost at one third of its length. They continue on the inside of the proboscis until they reach the buccal cavity where they discharge their secretions. The oesophageal bulb delimits the beginning of the mid-oesophagus (moe).

The mid-oesophagus is quite narrow up to the section where the short duct of the Gland of Leiblein (gle) enters it. This gland is dark brown and elongated,

accompanying the posterior oesophagus (poe) almost in its entirely length. The posterior oesophagus thickens slightly before entering in the stomach.

The foot (ft) is very thick and short (Fig. 9). The short proboscis is quite muscular. The walls have a thick outer layer of cuticle (cut). Inside the proboscis (prb) large mucous glands (glm) can be seen. The anterior oesophagus (aoe) has on both sides the large openings of the salivary ducts (sd).

2. Morphology of the reproductive systems

Bifurcium bicanaliferum (Figs. 10, 13)

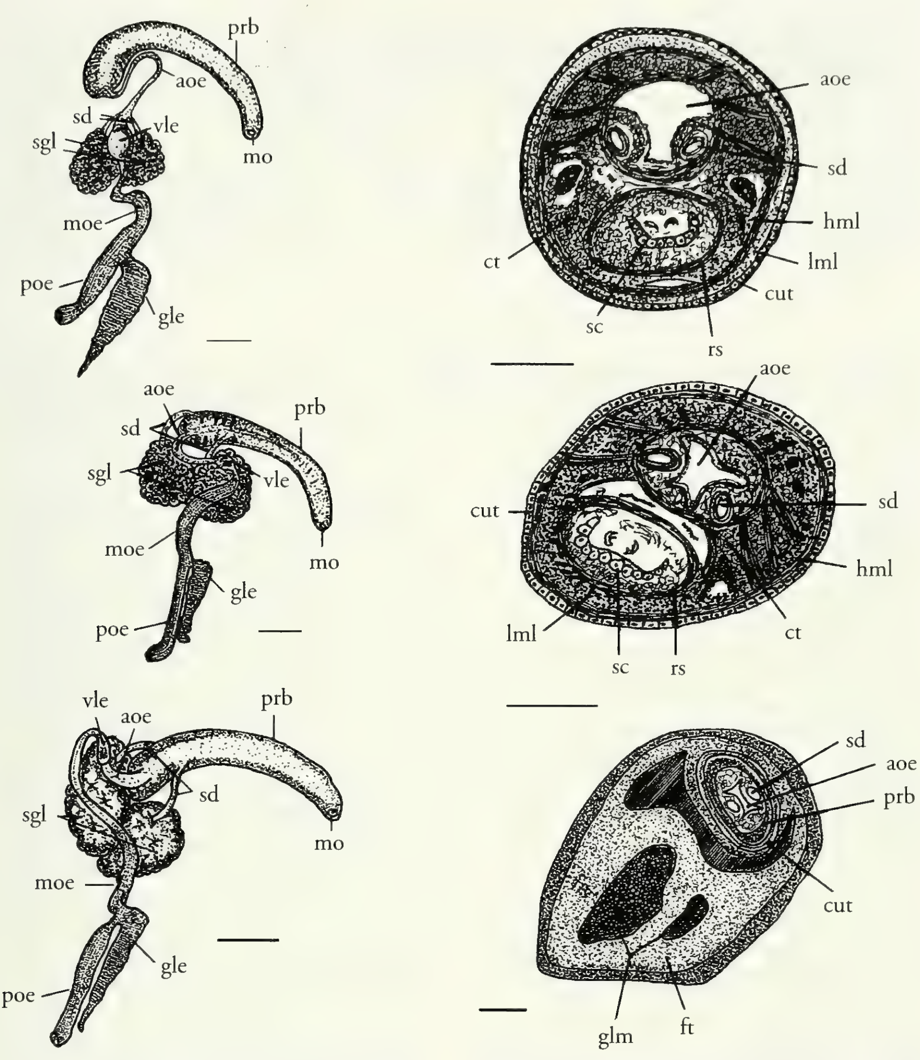
The bright yellow ovary (Fig. 10; ov) is located laterally relative to the digestive gland from which is separated by a layer of connective tissue. The oviduct (ovd) is relatively short; it runs parallel to the body wall and enters the albumen gland (alb) located near the kidney. The capsule gland (cgl) follows. At first glance, the two glands are almost indistinguishable from each other. Nevertheless, transversal and longitudinal sections of both organs show the presence of a small internal septum dividing both glands. Histological sections show the presence of more glandular tissue in the section corresponding to the albumen gland than after the internal septum. The vestibule (vsb) is very short and is located at the end of the capsule gland, followed by the female aperture (fop) which drains directly to the mantle cavity next to the anus.

The testis (Fig. 13; tes), share with the digestive gland the posterior part of the visceral cavity. The testis are located laterally to the digestive gland and from it the short testicular duct (ted) runs parallel to the stomach; after a short while it becomes extremely convoluted and becomes the seminal vesicle (sev). In the posterior region of the body mass, the seminal vesicle straightens out again and becomes the vas deferens (vd), a very thin and quite long duct that runs parallel to the rectum and the body wall until it reaches the base of the penis (pen). It enters the penis becoming the penial duct (pd), which runs centrally inside it. It is a convoluted tube that opens at the tip of the male organ. In resting animals, the penis is curved backwards along the right side of the body and rests in the penial pouch. The penis measures 11 mm long and is thickened in its middle part, tapering towards the tip. Its ventral side is somewhat wrinkled and dorso-ventrally flattened.

Sincola (*Dorsina*) *gibberula* (Figs. 11, 14)

The yellowish colored ovary (Fig. 11; ov) is lateral to the digestive gland, and separated from these by connective tissue. Follows a short and somewhat sinuous oviduct (ovd) that runs parallel to the body wall and enters the albumen gland (alb). A small external membrane connects the albumen and the capsule glands (cgl). Histological sections show the presence of a relatively deep internal septum dividing the two regions. The tissues present in both are also different, the first being much more glandular than the second. Both organs are located near the kidney. The vestibule (vsb) is well delineated in this species and runs from the anterior region of the capsule gland parallel to the rectum until it ends in the female opening (fop) located contiguous to the anus.

The testis (Fig. 14; tes) are located in the visceral cavity near the digestive gland, in a lateral position. The testicular duct (ted) is relatively long, runs parallel to the stomach and, soon after leaving the testis, starts to convolute,



Figures 4, 5. *Bifurcium bicanaliferum*. 4: macromorphology of the anterior alimentary tract; 5: transverse section of proboscis. Figures 6, 7. *Sincola (Dorsina) gibberula*. 6: macromorphology of the anterior alimentary tract; 7: transverse section of proboscis. Figures 8, 9. *Clavistrombina clavulus*. 8: macromorphology of the anterior alimentary tract; 9: transverse section of proboscis. Abbreviations. aoe: anterior oesophagus; ct: connective tissue; cut: cuticle; ft: foot; gle: gland of Leiblein; glm: gland of mucus;hml: helical muscle; lml: longitudinal muscle; mo: mouth; moe: middle oesophagus; poe: posterior oesophagus; prb: proboscis; rs: radular sac; sc: subradular cartilages; sd: salivary duct; sgl: salivary gland; vle: valve of Leiblein. Scale bars, 4, 6, 8: 2 mm; 5, 7, 9: 250 µm

Figuras 4, 5. Bifurcium bicanaliferum. *4: macromorfología del tracto alimentario anterior; 5: sección transversal de la probóscide. Figuras 6, 7.* Sincola (Dorsina) gibberula. *6: macromorfología del tracto alimentario anterior; 7: sección transversal de la probóscide. Figuras 8, 9.* Clavistrombina clavulus. *8: macromorfología del tracto alimentario anterior; 9: sección transversal de la probóscide. Abreviaturas. aoe: esófago anterior; ct: tejido conectivo; cut: cutícula; ft: pie; gle: glándula de Leiblein; glm: glándula del mucus;hml: múscula helicoidal; lml: múscula longitudinal; mo: boca; moe: esófago medio; poe: esófago posterior; prb: probóscide; rs: saco radular; sc: cartílagos subradulares; sd: conducto salivar; sgl: glándula salivar; vle: válvula de Leiblein. Escalas, 4, 6, 8: 2 mm; 5, 7, 9: 250 µm*

forming the seminal vesicle (sev). This has a whitish coloration and is located laterally to the stomach. At the posterior end, the gonadal duct becomes straight again forming the vas deferens (vd). The later is thick, not very long and runs parallel to the rectum along the body walls and enters the base of the penis (pen). Here it forms the penial duct (pd) that runs along and inside the penis, opening at its tip. The penis of this species is quite short, only seven millimeters long, and thickened throughout most of its way. Its surface is smooth and flattened in the dorso-ventral region. At rest, it is tucked in the penial pouch located in the dorsal region of the body wall.

Clavistrombina clavulus (Figs. 12, 15)

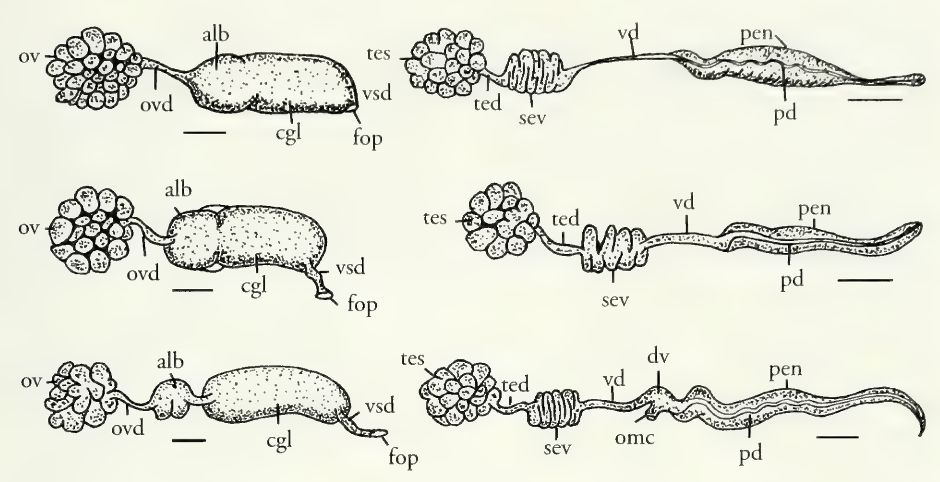
The female ducts of this species (Fig. 12) show several differences from the two previous species. The ovary (ov) is yellow and has a lateral position relative to the digestive gland, from which it is separated by a layer of connective tissue. The long oviduct (ovd) is sinuous and divided into two parts. It runs parallel to the body wall, curves and enters the completely delimited albumen gland (alb), which is located laterally to the kidney. After traversing the albumen gland, the gonadal duct leaves it, curves again and enters the capsule gland (cgl). The later has a bean shape and is located anteriorly to the kidney. From its posterior section starts the long and plain vestibule (vsb), which runs parallel to the rectum and opens near the anus in the female opening (fop).

Both the testis (Fig. 15; tes) and the digestive gland are located posteriorly in the visceral mass. A short testicular duct (ted) curves once after leaving the testis, and soon becomes coiled forming the seminal vesicle (sev). Both the testicular duct and the seminal vesicle are located parallel to the stomach. After the seminal vesicle, the duct becomes straight again forming a long conduct, the vas deferens (vd) which runs parallel to the rectum and ventrally gives origin to a short diverticulum (dv). The later connects with the mantle cavity through an opening (omc). Immediately after the diverticulum, the vas deferens enters the base of the penis (pen) and becomes the penial duct (pd), running centrally and appears as a convoluted and long tube which opens at the tip of the penis. The penis is very long, over 12 mm in length, smooth, and flattened dorso-ventrally. As in the two previous species, the penis rests in the penial pouch located in the posterior dorsal region of the body.

DISCUSSION

Both the anterior alimentary tract and the reproductive systems of the three studied species are similar in their general plan. In what concerns the anterior alimentary tract, the most important difference lies in the insertion of the salivary ducts, which in *B. bicanaliferum* occurs in the anterior oesophagus just before the Valve of Leiblein, whereas in both *S. gibberula* and *C. clavulus* it happens in the posterior region of the proboscis. *B. Bifurcium* also presents a much longer proboscis and anterior oesophagus, as well as a larger oesophageal bulb than the other two species, in spite of the fact that the animal in itself is smaller in size (range size for *B. bicanaliferum*: 9–13 mm; *S. gibberula*: 9–12 mm; *C. clavulus*: 14–25 mm).

At the level of the reproductive systems, *C. clavulus* shows several differences mostly within the accessory structures. Of particular interest is the existence of a well defined albumin gland in females and a mantle opening (the diverticulum) in the males. The later is of special interest as it bears on the evolution of the open reproductive system. This



Figures 10-12. Macromorphology of the female ducts. 10: *Bifurcium bicanaliferum*; 11: *Sincola (Dorsina) gibberula*; 12: *Clavistrombina clavulus.* Figures 13- 15. Macromorphology of the male ducts. 13: *Bifurcium bicanaliferum*; 14: *Sincola (Dorsina) gibberula*; 15: *Clavistrombina clavulus.* Abbreviations: alb: albumen gland; cgl: capsule gland; dv: diverticulum; fop: female opening; omc: opening in mantle cavity; ov: ovary; ovd: oviduct; pd: penial duct; pen: penis; ted: testicular duct; tes: testis; sev: seminal vesicle; vd: vas deferens; vsb: vestibule. Scale bars. 10, 11: 3 mm; 12: 5 mm; 13, 14: 4 mm; 15: 10 mm.

Figuras 10-12. Macromorfología de los conductos femeninos. 10: Bifurcium bicanaliferum*; 11:* Sincola (Dorsina) gibberula*; 12:* Clavistrombina clavulus. *Figuras 13- 15. Macromorfología de los conductos masculinos. 13:* Bifurcium bicanaliferum*; 14:* Sincola (Dorsina) gibberula*; 15:* Clavistrombina clavulus. *Abreviaturas: alb: glándula del albumen; cgl: glándula de la cápsula; dv: divertículo; fop: abertura femenina; ov: ovario; omc: abertura en la cavidad del manto; ovd: oviducto; pd: conducto peneal; pen: pene; ted: conducto testicular; tes: testis; sev: vesícula seminal; vd: vaso deferente; vsb: vestíbulo. Escalas. 10, 11: 3 mm; 12: 5 mm; 13, 14: 4 mm; 15: 10 mm.*

condition is typical in most mesogastropods and is considered to be the primitive state (JOHANSSON, 1942; FRETTER, 1946). In spite of the fact that most neogastropods present a fused reproductive duct, the presence of an opening to the mantle cavity occur in several columbellids, olivids, muricids, buccinids, and turrids (MARCUS AND MARCUS, 1959, 1962; SMITH, 1967; HOUSTON, 1976; HOUSTON AND HATFIELD, 1981). It would appear that this means a retention of the primitive state for this species.

The columbellid reproductive system combines very primitive features, like a gonopericardial-pallial communication, with advanced ones as it is the pouch for the resting penis. Based on this, MARCUS AND MARCUS (1962) divide the whole family into two groups: a) males with a seminal vesicle and no prostate, and females with an albumen gland and sperm storing organ; b) absence of seminal vesicle and presence of prostate in males combined with absence of albumen gland and sperm storing organ in females (sperm is kept in the pericardium).

None of the species studied presents either a bursa copulatrix or a prostate gland. This means that they wouldn't very well fit neither of the morphological divisions defined above. Interesting is also the fact that in spite of having an open male duct, *C. clavulus* has a higher compartmentalized reproductive system, whereas the other two species have a more generalized, with less distinct accessory structures, system. Whereas this means a more or less advanced condition it is difficult to say.

The greater similitude between *Bifurcium* and *Sincola* is especially interesting. These genera first appear in the early Miocene in fossil deposits of the Dominican Republic, Caribbean Sea. On the other hand, *Clavistrombina* is a recent genus of the eastern Pacific. Whereas these differences in times of origination could bear on the internal anatomy of the taxa is difficult to know. Many more studies of other species of these and other genera of the group are still needed in order to be able to make definite conclusions about the functional and ecological relationships of the reproductive systems and their evolution.

AKNOWLEDGEMENTS

A. Velarde, J. Jara, and F. Rodríguez assisted in the field and in the laboratory. J. Ceballos helped with the SEM photographs. A special word of thanks to F. Rodríguez who did the line drawings. I thank the personnel of the Naos Marine laboratory for their support with the day by day keeping of collections. I greatly appreciate the criticisms and kind remarks of Y. Kantor and R. Absalão which helped to improve the final version of the paper. This work is funded by the Smithsonian Tropical Research Institute and Walcott funds.

BIBLIOGRAPHY

Adams, H. and Adams, A., 1858. *The genera of Recent Mollusca; Arranged According to their Organization*. Vol. 1. London, John Van Voorst, 484 pp.

Bright, D. A. and Ellis, D. V., 1990. A comparative survey of imposex in northeast Pacific neogastropods (Prosobranchia) related to tributyltin contamination, and choice of a suitable bioindicator. *Canadian Journal of Zoology*, 68: 1915-1924.

Brown, S. C., 1969. The structure and function of the digestive system of the mud snail *Nassarius obsoletus* (Say). *Malacologia*, 9 (2): 447-500.

Cipriani, R. and Penchaszadeh, P., 1993. How does *Strombina* reproduce? Evidence from two Venezuelan species (Prosobranchia: Columbellidae). *The Veliger*, 36 (2): 178-184.

Cipriani, R., Fortunato, H., and Rodriguez, F., 1996. Replacement of the operculum in *Strombina, Clavistrombina, Bifurcium*, and *Sincola* (Gastropoda: Columbellidae): are the operculum characters reliable for systematic analysis? *Program and Abstracts, 62 American Malacological Union Meetings*, p.32.

De Maintenon, M., 1994. Evolution of *Columbella* (Neogastropoda: Columbellidae) in the Neogene American tropics. *Geological Society of America Meeting, Abstracts with Program*, 26: A-53.

De Maintenon, M., 1999. Phylogenetic analysis of the Columbellidae (Mollusca: Neogastropoda) and the evolution of herbivory from carnivory. *Invertebrate Biology*, 118 (3): 258-288.

Emerson, K. W., 1993. A new species of columbellid gastropod from the old world tropics. *The Nautilus*, 106 (4): 147-151.

Fortunato, H., 1998. Reconciling observed patterns of temporal occurrence with cladistic hypotheses of phylogenetic relationship. *American Malacological Bulletin*, 14 (2): 191-200.

Fortunato, H., 1999. Biogeography and the tempo of speciation in strombinid gastropods. *Abstracts, 7 Congress of the European Society for Evolutionary Biology*, II: 107.

Fortunato, H., 2002. Reproduction and larval development of the *Strombina*-group and related gastropods (Buccinoidea: Columbellidae): testing the use of the larval shell for inference of development in fossil species. In: Oliverio, M. and Chemello, R. (Eds): Systematics, Phylogeny, and Biology of the Neogastropoda. *Bollettino Malacologico*, supplement 4: 111-126.

Fortunato, H. and Jung, P., 1995. The Strombina-group (Neogastropoda: Columbellidae): a case study of evolution in the neotropics. *Geological Society of America Meeting, Abstracts with Program*, 27: A-52.

Fortunato, H., Penchaszadeh, P. E. and Miloslavich, P., 1998. Observations on the reproduction of *Bifurcium bicanaliferum* (Sowerby, 1832) (Gastropoda: Columbellidae: *Strombina*-group) from the Pacific coast of Panama. *The Veliger*, 41 (2): 208-211.

Fretter, V., 1941. The genital ducts of some British stenoglossan prosobranchs. *Journal Marine Biological Association of the United Kingdom*, 25: 173-211.

Fretter, V., 1946. The genital ducts of *Theodoxus, Lamellaria* and *Trivia*, and a discussion of their evolution in the prosobranchs. *Journal of Marine Biological Association of the United Kingdom*, 26: 312-351.

FRETTER, V. AND GRAHAM, A., 1962. *British Prosobranch Molluscs. Their Functional Anatomy and Ecology*. The Ray Society, London, 755 pp.

GRAHAM, A., 1949. The molluscan stomach. *Transactions of the Royal Society Edinburgh*, 61 (3): 737-778.

GURALNICK, R. AND DE MAINTENON, M., 1977. Formation and homology of radular teeth; a case study using columbellid gastropods. *Journal of Molluscan Studies*, 14 (1-4): 1-9.

HARASEWYCH, M. G., 1984. Comparative anatomy of four primitive muricacean gastropods: implications for trophonine phylogeny. *American Malacological Bulletin*, 3: 11-26.

HARASEWYCH, M. G., 1990. Ovophagy in *Anachis avara* (Say, 1822) (Gastropoda: Columbellidae). *The Nautilus*, 104 (2): 76.

HATFIELD, E. B., 1979. Food sources for *Anachis avara* (Columbellidae) and a discussion of feeding in the family. *The Nautilus*, 93 (1): 40-43.

HOUBRICK, R. S., 1983. A new *Strombina* species (Gastropoda: Prosobranchia) from the tropical western Atlantic. *Proceedings of the Biological Society of Washington*, 96 (3): 349-354.

HOUSTON, R. S., 1976. The structure and function of neogastropod reproductive systems: with special reference to *Columbella fuscata* Sowerby, 1832. *The Veliger*, 19 (1): 27-46.

HOUSTON, R. S. AND HATFIELD, E. B., 1981. The reproductive system of the western Atlantic *Anachis avara* (Gastropoda: Columbellidae). *The Nautilus*, 95 (3): 136-139.

HUMASON, G. L. 1962. Animal tissue techniques. W.H. Freeman and Group, S. Francisco and London, 468 pp.

JACKSON, J. B. C., P. JUNG, A. G. COATES AND COLLINS, L. S.,. 1993. Diversity and Extinction of tropical American Mollusks and Emergence of the Isthmus of Panama. *Science*, 260: 1624-1626.

JACKSON, J. B. C., JUNG, P., AND FORTUNATO, H. 1996. Paciphilia revisited: transisthmian evolution of the *Strombina*-group (Gastropoda: Columbellidae). In Jackson, J. B. C., Coates, A. G., and Budd, A. F. (Eds.): *Evolution and Environment in Tropical America*, Univ. of Chicago Press, 234-270.

JOHANSSON, J., 1942. Von diaulen Geschlechtsapparaten bei den Prosobranchiern. *Arkives Zoologisches*, 34 (12): 1-10.

JUNG, P., 1989. Revision of the *Strombina*-group (Gastropoda: Columbellidae), fossil and living. Distribution, Biostratigraphy, and Systematics. *Mémoires Suisses de Paléontologie*, 111: 1-298.

KANTOR, Y. I., 1991. On the morphology and relationships of some oliviform gastropods. *Ruthenica*, 1 (1-2): 17-52.

KANTOR, Y. I. AND MEDINSKAYA, A. I., 1991. Morphology and feeding of *Mitrella burchardi* (Gastropoda: Columbellidae). *Asian Marine Biology*, 8: 25-33.

KOOL, S. P., 1993. Phylogenetic analysis of the Rapaninae (Neogastropoda: Muricidae). *Malacologia*, 35 (2): 155-259.

MARCUS, E. AND MARCUS, E., 1959. Studies on "Olividae". *Boletim da Faculdade de Filosofia, Ciências da Universidade de São Paulo, Zoologia*, 22: 99-188.

MARCUS, E. AND MARCUS, E., 1960. On *Hastula cinerea*. *Boletim da Faculdade de Filosofia, Ciências da Universidade de São Paulo, Zoologia*, 24: 11-30.

MARCUS, E. AND MARCUS, E., 1962. Studies on the Columbellidae. *Boletim da Faculdade de Filosofia, Ciências e Letras da Universidade de São Paulo*, 261 (24): 11-24.

MARCUS, E. AND MARCUS, E., 1964. On the doveshell *Anachis pulchella* (Blainv.). *Anais da Academia Brasileira de Ciências*, 36 (3): 359-366.

MEDINSKAYA, A. I., 1992. Anatomy of the proboscis walls in Neogastropoda (Gastropoda) and its connection with diet and feeding mechanism. *Ruthenica*, 2 (1): 27-35.

MEDINSKAYA, A. I., 1993. Anatomy of the stomach of some Neogastropoda from the offshore zone of the Japan Sea. *Ruthenica*, 3 (1): 17-24.

PONDER, W. F., 1970. The morphology of *Alcithoe arabica* (Gastropoda: Volutidae). *Malacological Review*, 3: 127-165.

PONDER. W. F., 1972. The morphology of some mitriform gastropods with special reference to their alimentary and reproductive systems (Neogastropoda). *Malacologia*, 11 (2): 295-342.

PONDER, W. F., 1973. The origin and evolution of the Neogastropoda. *Malacologia*, 12: 295-338.

RADWIN, G. E., 1977a. The family Columbellidae in the western Atlantic. *The Veliger*, 19 (4): 403-417.

RADWIN, G. E., 1977b. The family Columbellidae in the western Atlantic. Part IIa. – The Pireninae. *The Veliger*, 20 (2): 119-133.

RADWIN, G. E., 1978. The family Columbellidae in the western Atlantic. Part IIb. – The Pireninae (continued). *The Veliger*, 20 (4): 328-344.

RISBEC, J., 1954. Considérations sur l'anatomie des Columbelles (Gastéropodes Prosobranches). *Bulletin de la Societé de Zoologie de France*, 79 (2/3):127-134.

SMITH, E. H., 1967. The reproductive system of the British Turridae (Gastropoda: Toxoglossa). *The Veliger*, 10 (2): 176-187.

SYSOEV, A. V., 1991. Preliminary analysis of the relationships between turrids (Gastropoda, Toxoglossa, Turridae) with different types of radular apparatus in various Recent and fossil faunas. *Ruthenica*, 1 (1-2): 53-66.

TAYLOR, D. W., AND SOHL, N. F., 1962. An outline of gastropod classification. *Malacologia*, 1 (1): 7-32.

TAYLOR, J. D., MORRIS, N. J., AND TAYLOR, C. N., 1980. Food specialization and the evolution of predatory prosobranch gastropods. *Palaeontology*, 23 (2): 375-409.

THIELE, J., 1929. *Handbook of Systematic Malacology, Part I (Loricata; Gastropoda: Prosobranchia)*. Bhatti J. S., translator, Bieler R. and Mikkelsen P. M. (Eds.), Smithsonian Institution Libraries and the National Science Foundation, Washington, D. C., 1992, 625 pp.

The genus *Schwartziella* in Senegal (Gastropoda, Rissoidae)

El género *Schwartziella* en Senegal (Gastropoda, Rissoidae)

Emilio ROLÁN* and José María HERNÁNDEZ**

Recibido el 17-II-2003. Aceptado el 24-VI-2003

ABSTRACT

The species of the genus *Schwartziella* from Senegal are revised; five species are illustrated, of which one is new to science. *S. crassior*, usually considered a synonym of *S. africana* is now considered a valid species. Two species are considered similar to others from the Cape Verde archipelago. The shell characters of all the species and some information on soft parts, opercula and radulae of some of them are shown.

RESUMEN

Se revisan las especies del género *Schwartziella* recolectadas en Senegal, mostrando cinco especies, de las cuales una de ellas es nueva para la ciencia. Se da validez al taxon *S. crassior*, hasta ahora considerado una forma de *S. africana*. Dos especies se consideran similares a otras descritas en el Archipiélago de Cabo Verde. Se muestran gráficamente los caracteres de la concha, y alguna informacion sobre partes blandas, opérculo y rádula de algunas de las especies estudiadas.

KEY WORDS: Rissoidae, *Schwartziella*, Senegal, new species.
PALABRAS CLAVE: Rissoidae, *Schwartziella*, Senegal, especie nueva.

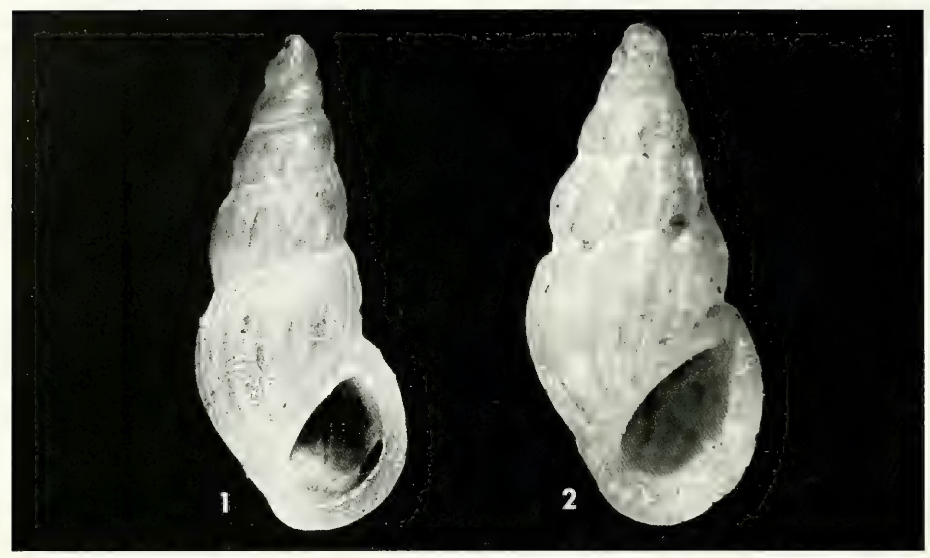
INTRODUCTION

DAUTZENBERG (1912) described *Rissoina africana* from Senegal and mentioned the variety *crassior* being represented by two figures, plate 2, figs. 5-6 and 7-8 respectively. The types of those taxa are in the MNHN (Figs. 1, 2).

GOFAS (1999) made a revision of the African species of Rissoidae and concluded that both taxa were the same species. *Schwartziella africana* and *Rissoina punctostriata*, descrita por TALAVERA (1975) were the sole species of this subfamily considered present on the West African coast. ROLÁN AND LUQUE (2000) revised the subfamily Rissoininae from the Cape Verde Archipelago showing the existence of an important diversification of this subfamily with 29 species, mainly in the genus *Schwartziella*, including 26 new species.

In sediment material collected in Dakar by Jacques Pelorce, and by both authors, a large quantity of shells of *Schwartziella* were examined; and the present work presents the information obtained from this study. Some specimens had opercula and remains of soft parts, but it was very difficult to obtain radulae from all the species because in many cases the soft parts were damaged and the radula was not found or was in very bad condition.

* Investigador del Museo de Historia Natural, Campus Universitario Sur, 15782, Santiago de Compostela.
** Capitán Quesada 41, 35460 Gáldar, Gran Canaria, Spain.



Figures 1, 2: *Schwartziella africana* and *S. africana* var. *crassior*, both 3.0 mm, Dakar (MNHN).
Figuras 1, 2: Schwartziella africana *y* S. africana *var.* crassior, *ambas de 3,0 mm, Dakar (MNHN).*

Abbreviations

MNCN Museo Nacional de Ciencias Naturales, Madrid
MNHN Musèum National d'Histoire Naturelle, Paris
NNM Natuurhistorischen Museum, Leiden
CER collection of Emilio Rolán
CJH collection of José María Hernández
CJP collection of Jacques Pelorce

SYSTEMATICS

Family RISSOIDAE Gray, 1847
Subfamily RISSOININAE Stimpson, 1865
Genus *Schwartziella* Nevil, 1881

Schwartziella africana (Dautzenberg, 1912) (Figs. 1, 3, 4, 12, 17, 22, 26, 27)

Rissoina africana Dautzenberg, 1912. Mission Gruvel. *Ann. Inst. Océanogr.*, 5 (3): 48-49, pl. 2, figs. 5-6. [Type locality: Baie de Hann, Senegal].

Type material: Holotype (Fig. 1) in MNHN, 3 mm.
Other material examined: 728 shells (of which about 40 with operculum and remaining soft parts), from several localities in Dakar, Senegal (for locality and collection details, see Table I, where sympatric species are also listed).

Description: See DAUTZENBERG (1912) and GOFAS (1999), where a general description of the shell is given. We add the following details: The shell (Figs. 1, 3, 4) is whitish. The protoconch (Fig. 17) is of the non-planktotrophic type with a diameter of about 315 µm and of one spiral whorl; its surface has irregular flat elevations. The teleoconch has five whorls with a slightly curved profile; the axial ribs are opisthocline, almost rectilinear and the interspaces are of similar size; there are 15-

Table I. Material studied from the Dakar area in the CER, CJP and CJH.
Tabla I. Material estudiado del área de Dakar en las colecciones CER, CJP y CJH.

	S. africana	*S. crassior*	*S. yragoae*	*S. cf. puncticulata*	*S. cf. hoenselaari*
Le Tacoma 6-12 m (CER)	61		224	6	
Le Tacoma 13 m, Epave (CER)	152		528	12	
Le Tacoma 15 m Epave (CER)	167		375	21	
Ngor, 14 m, in Palythoa (CER)	81	5	3	24	7
Madeleines 15-30 m (CER)	36	2	53	23	3
East Madeleines 6-14 m (CER)	36	1	140	1	
NE Madeleines, Oune, 18 m (CER)	20	1	60		
Petit Thiouriba, 33 m (CER)	3		13	1	
Grand Thiouriba, 30 m (CER)	7		8	1	
Cap Vert, Pa Maquete, 33 m (CER)	21				
Between Gorée and Dakar, 20 m (CER)		24	29		
Ngor, in beach sediments (CER)	50	4		6	
Dahomey, 27-30 m (CER) in Bouquet			6	5	
S of Gorée, 5-8 m (CER)	10	2	7	8	5
Grand Thiouriba, 40 m (CJP)	10		91		
Tacoma Epave, 13 m (CJP)	22		60		
Les Madeleines, 10-30 m (CJP)	3				
S of Gorée 3-6 m (CJH)	8	8	5	4	11
Petit Thiouriba, 30-35 m (CJH)	1	3	3	1	
Seminoles, 20-25 m (CJH)	1			2	
S of Gorée, 3-6 m (CJH)	37	27	11		5
Oceanium Diver Center, 0-6 m (CJH)	2	5	1		
Total	728	82	1617	115	31

17 ribs on the last whorl (Fig. 12). When the shell is fresh, it is rather translucent and the soft parts or sand can be seen in its interior. Microsculpture (Fig. 22) of irregular threads visible mainly on the intervals between the ribs.

Dimensions: most of the material studied is between 2.8 and 3.5 mm high; in some populations, shells can reach 3.7 mm.

Periostracum evident and yellowish to orange in color.

Operculum (Figs. 26, 27) whitish, transparent and with a marginal nucleus.

Radula (not illustrated) was examined by optical microscope and showed no difference from that of *S.* cf. *puncticulata* (see below).

Distribution: Known only from Senegal. In the Dakar area, it is one of the most common species being present in nearly all of the collecting locations.

Remarks: *S. africana* was the first Rissoininae found on the West African coast as mentioned by DAUTZENBERG (1912).

We have made measurement of the the larger shells of our material from several lots and they always were smaller than 3.7 mm. The size referred in GOFAS (1999) as up to 5.25 mm, may be due of the inclusion of shells of other species in this taxon which usually does not reach this size.

S. africana differs from any other from European and Cape Verde Islands species mainly because of its transparency, scarcely curved profile, opisthocline axial ribs, and its fine microsculpture.

From other Senegal species living sympatrically, Table II shows the most important differences.

Table II. Characters of the species from Dakar.
Tabla II. Caracteres de las especies de Dakar.

	diameter of the protoconch	size in mm	consistency	axial ribs on last whorl	ribs	position of ribs	space between ribs	profile of whorls
S. africana	316	2.8-3.7	solid	15-17	almost rectilinear	opisthocline	same as ribs	slightly convex +
S. crassa	291	2.5-3.4	very solid	11-13	almost rectilinear	orthocline	wider than the ribs	slightly convex ++
S. yragoae spec. nov.	312	2.4-3.4	less solid	8-11	S-curved	strongly opisthocline	double that of ribs	convex +++
S. cf. *puncticulata*	315	3.8-4.1	very solid	12-14	almost rectilinear	orthocline or very slightly opisthocline	similar to ribs	strongly convex on upper part +++
S. cf. *hoenselaari*	328	2.5-3.0	fragile	8-10	almost rectilinear	orthocline or very slightly opisthocline	wider than the ribs	slightly convex +

Schwartziella crassior (Dautzenberg, 1912) (Figs. 2, 5, 6, 13, 18, 24)

Rissoina africana var. *crassior* Dautzenberg, 1912. Mission Gruvel. *Ann. Inst. Océanogr.*, 5 (3): 48, pl. 2, figs. 7-8. [Type locality: Baie de Hann, Senegal].

Type material: Holotype (Fig. 2) in MNHN, 3 mm.
Material examined: 82 shells from the Dakar area (see Table I for further explanation).

Description: DAUTZENBERG (1912) dedicates only one paragraph to this species which he considers as simply a form of *S. africana*. GOFAS (1999) also considers this species as a form of *S. africana*. Thus, a redescription is necessary.

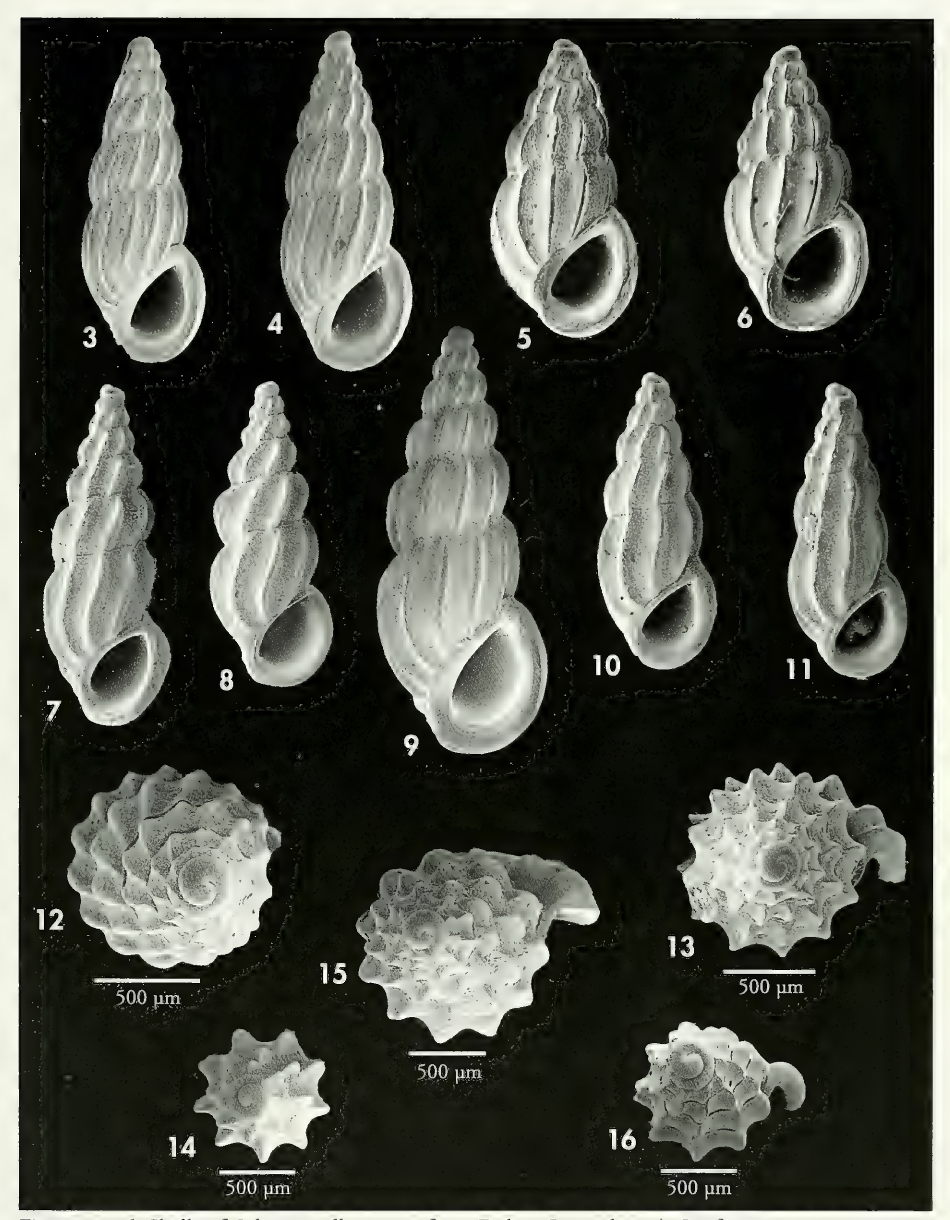
Shell (Figs. 2, 5, 6) length up to 3.4 mm, maximum width 1.5 mm, solid, elongate-conic, not transparent.

Protoconch (Fig. 18) of 1 whorl of about 290 µm maximum diameter, of non-planktotrophic type, with no spiral sculpture; transition to teleoconch abrupt. Microsculpture formed by very numerous irregular flat prominences.

Teleoconch of 4-4 $^{1}/_{2}$ whorls, slightly convex, not angulated below the suture; last whorl convex; suture shallow but evident. Color whitish.

Axial sculpture (Fig. 13) consisting of prominent rounded narrow orthocline (slightly opisthocline on early whorls), very distantly spaced axial ribs; numbering 11-13 on the last whorl. Spiral sculpture almost invisible at low magnification. Microsculpture (Fig. 24) with irregular threads visible mainly in the interspaces between ribs.

Aperture D-shaped, small to medium-sized; inner lip thick; columellar side weakly concave; anterior channel absent; outer lip strongly opisthocline with a very thick external varix; peristome narrow with about 4



Figures 3-16. Shells of *Schwartziella* species from Dakar, Senegal. 3, 4: *S. africana*, 3.1, 3.3 mm; 5, 6: *S. crassior*, 2.8, 2.4 mm; 7, 8: *S. yragoae*, holotype, 3,3 mm (MNCN) and paratype, 2.8 mm (MNHN); 9: *S.* cf. *puncticulata*, 4.1 mm; 10, 11: *S. hoenselaari*, 2.5, 2.5 mm; 12: *S. africana*, apical view; 13: *S. crassior*, apical view; 14: *S. yragoae*, paratype (CER), apical view; 15: *S.* cf. *puncticulata*, apical view; 16: *S. hoenselaari*, apical view.

Figuras 3-16. Conchas de las especies de Schwartziella *de Dakar, Senegal. 3, 4:* S. africana, *3,1, 3,3 mm; 5, 6:* S. crassior, *2,8, 2,4 mm; 7, 8:* S. yragoae, *holotipo, 3,3 mm (MNCN) y paratipo, 2.8 mm (MNHN); 9: S. cf.* puncticulata, *4,1 mm; 10, 11:* S. hoenselaari, *2,5, 2,5 mm; 12:* S. africana, *vista apical; 13:* S. crassior, *vista apical; 14:* S. yragoae, *vista apical; 15:* S. *cf.* puncticulata, *vista apical; 16:* S. hoenselaari, *vista apical.*

parallel lines toward the inner part of the aperture.

Distribution: Known only from some localities in Dakar area. It is generally uncommon and was not found in all localities (see Table I for the places of collecting).

Remarks: This species is consistently different from *S. africana*, but only by examining a large quantity of shells it is possible to appreciate these constant differences. In comparison with *S. africana*, *S. crassior* is smaller, wider, and not transparent; the axial ribs are orthocline and less numerous.

The similar species from the Cape Verde Islands may be differentiated: *S. typica* Rolán and Luque, 2000 has a spiral cord on the protoconch and different microsculpture; *S. luisi* Rolán and Luque, 2000 has spiral cords; *S. minima* Rolán and Luque, 2000 is smaller and has more prominent spiral sculpture; *S. hoenselaari* Rolán and Luque, 2000 has a spiral sculpture with smooth interspaces and the axial ribs are lower in number.

Schwartziella yragoae spec. nov. (Figs. 7, 8, 14, 19, 29, 30, 32)

Type material: Holotype (Fig. 7) of 3.3 mm height, deposited in MNCN 15.05/46610; paratypes in the following collections: MNHN (1); CER (25); CJH (10) and CJP (10).

Other material examined: 1617 shells (about 30 with remains of the soft parts and operculum), from the Dakar area (see Table I for additional explanation).

Type locality: Dakar, Senegal.

Etymology: The species is named after Cristina Garcia Yrago, wife of the junior author, for her many years of patience and cooperation.

Description: Shell (Figs. 7, 8) length up to 3.5 mm, maximum width 1.3 mm, not very solid, elongate-conic, not transparent.

Protoconch (Fig. 19) of a little more than 1 whorl of about 310 µm of maximum diameter, of non-planktotrophic type, without any spiral sculpture; transition to teleoconch abrupt. Microsculpture formed by very numerous irregular flat prominences.

Teleoconch of 4-5 strongly convex whorls, not angulated below the suture; last whorl strongly convex; suture deep and evident. Color whitish.

Axial sculpture (Fig. 14) consisting of prominent sharp, narrow, S-curved, strongly opisthocline separate axial ribs, which seem to extend from whorl to whorl, being less prominent near the base. Their number is 9-11 on the last whorl. Spiral sculpture not evident without magnification. Microsculpture formed by irregular threads visible mainly in the interspaces between the ribs.

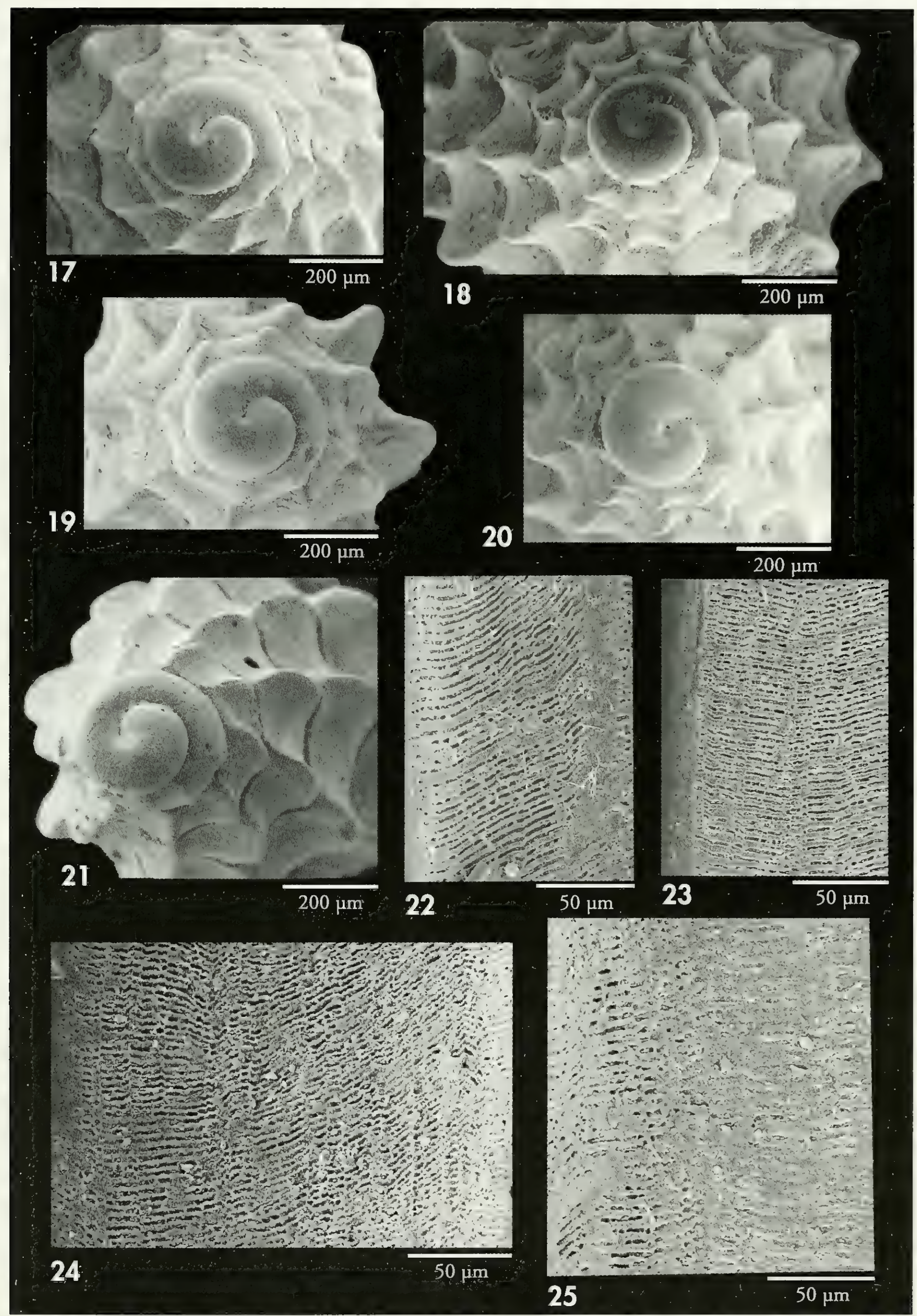
Aperture D-shaped, medium sized; inner lip thick; columellar side weakly concave; anterior channel nearly absent; outer lip strongly opisthocline, with thick external varix; with a few parallel lines toward the inner part of the aperture.

Operculum (Figs. 29, 30) whitish, transparent, with marginal nucleus.

Radula (Fig. 32) with a rachidian tooth with a pair of basal denticles, and a scarcely prominent central cusp with 5-7 small cusps at each side. Inner marginal teeth finely denticulate; outer marginal teeth without any denticles on the external margin.

Distribution: The species is known from Dakar, where it is the most common species collected at practically all the collecting points.

Remarks: S. *yragoae* spec. nov. is very different from all the species known from Cape Verde Islands and Senegal for the following particular characters: the S-curved, strong, sharp and narrow axial ribs, numbering 11 or fewer on the last whorl, and the very convex whorls and deep suture. This species lives sympatrically with the other species present in Senegal without intergrades.



Figures 17-21. Protoconchs: 17: *S. africana*; 18: *S. crassior*; 19: *S. yragoae* spec. nov.; 20: *S.* cf. *puncticulata*; 21: *S. cf. hoenselaari*. Figures 22-25: Microsculpture. 22: *S. africana*; 23: *S.* cf. *puncticulata*; 24: *S. crassior*; 25: *S. cf. hoenselaari*.

Figuras 17-21. Protoconchas: 17: S. africana*; 18:* S. crassior*; 19:* S. yragoae *spec. nov.; 20:* S. *cf.* puncticulata*; 21:* S. cf. hoenselaari. *Figuras 22-25: Microescultura. 22:* S. africana*; 23:* S. *cf.* puncticulata*; 24:* S. crassior*; 25:* S. cf. hoenselaari.

Schwartziella cf. *puncticulata* Rolán and Luque, 2000 (Figs. 9, 15, 20, 23, 28, 31, 33)

Schwartziella puncticulata Rolán and Luque, 2000. *Iberus*, 18 (1): 58, figs. 85-87.

Type material: Holotype in NNM. Paratypes, see ROLÁN AND LUQUE (2000).
Material examined: 5 live specimens, Dahomey, 10 Km south of Dakar, 27 m; 115 shells (five alive collected) from the Dakar area (see Table I for additional explanation).

Description: See ROLÁN AND LUQUE (2000). Shells from the Dakar population are figured (Figs. 9, 15), as well as the protoconch (Fig. 20) and microsculpture (Fig. 23).

The animal (Fig. 33) was observed alive: it is whitish in color, with narrow and elongate tentacles, the male has a curved penis.

Operculum (Figs. 28) whitish and transparent.

The radula (Fig. 31) has a rachidian tooth with a pair of basal denticles, and a prominent central cusp with 5-6 small cusps at each side. Lateral tooth with about 10 cusps at the inner border; inner marginal teeth finely denticulate; outer marginal teeth without any denticles on the external margin.

Distribution: If the present population is the same species as that described from Cape Verde Islands, it is known only from that archipelago and Senegal.

Remarks: We did not find important differences between these shells from Dakar and the Cape Verde material, therefore we included them tentatively in that taxon. The shells from Dakar are slightly smaller (up to 4.1 mm, against 4.5 in the Cape Verde shells); also the protoconch is smaller (about 315 µm against 360 for the Cape Verde shells). The shells frequently appear decollated at the apex, which is not the case in the Cape Verde populations. Finally, the microsculpture is more pitted in the Cape Verde shells than in the Dakar ones, where there are threads.

But all those differences are not very important and thus we consider probably both conspecific. Our only doubt arises how a species with non-planktotrophic development might be present in such widely separate places, but human action may be considered through the frequent traffic between the islands and the main coast.

Schwartziella cf. *hoenselaari* Rolán and Luque, 2000 (Figs. 10, 11, 16, 21, 25)

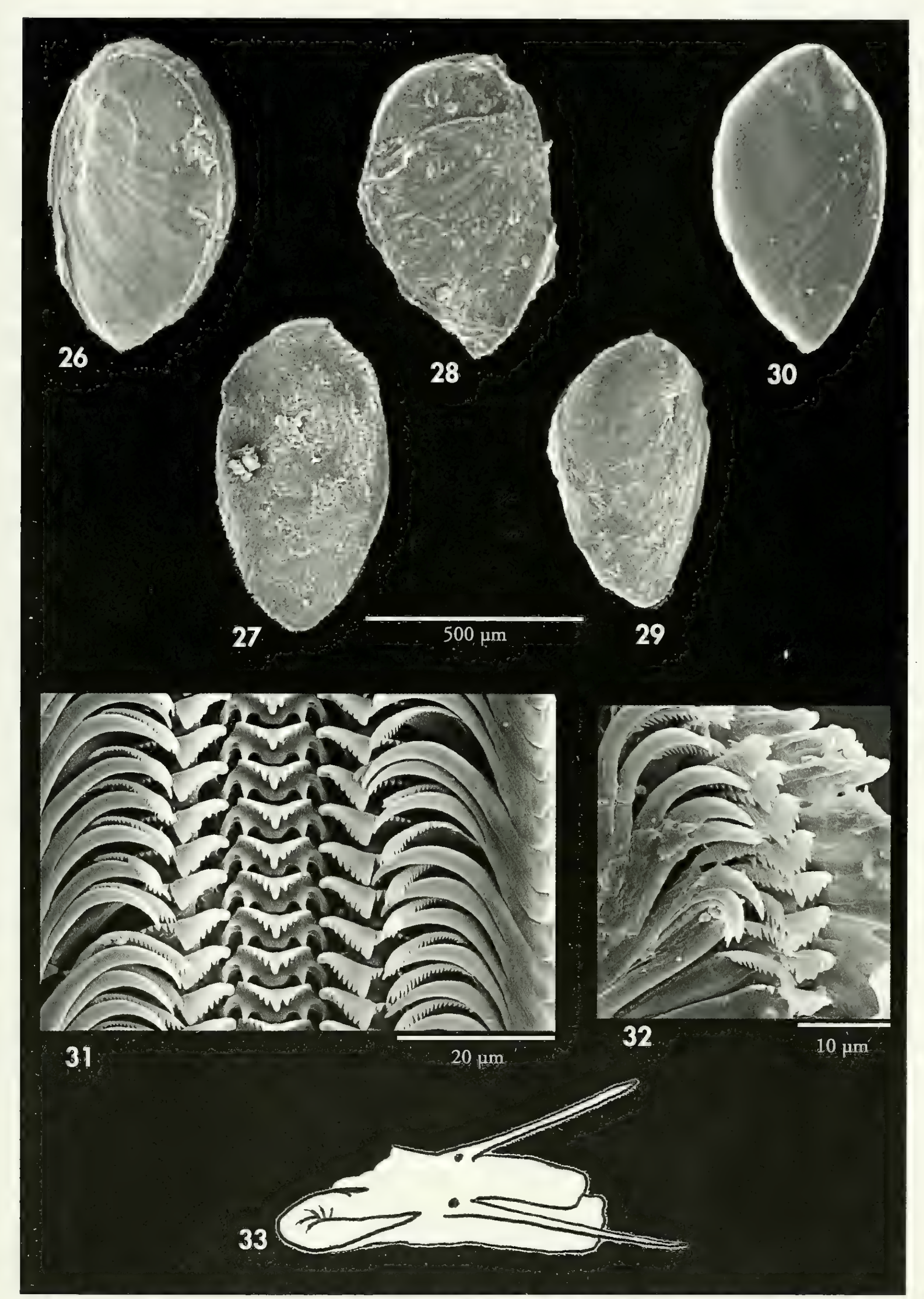
Schwartziella hoenselaari Rolán and Luque, 2000. *Iberus*, 18 (1): 60, figs. 88-92.

Type material: Holotype in NNM. Paratypes, see ROLÁN AND LUQUE (2000).
Material examined: 31 shells from the Dakar area (see Table I for more explanations).

Description: See ROLÁN AND LUQUE (2000). Shells from Dakar area are figured (Figs. 10, 11, 16), as well as the protoconch (Fig. 21) and the microsculpture (Fig. 25).

Distribution: If the present is the same species as described from Cape Verde, only known from this archipelago and Senegal.

Remarks: We did not find important differences between the shells from Dakar and those from Cape Verde, thus we included them tentatively in this taxon with the Cape Verde material. The shells from Dakar are slightly narrower than the holotype but not from other shells represented in the original description. The protoconch is smaller in the type material (about 300 µm against 315 for the Dakar shells), and the microsculpture is a little different, in the type material having alternating lines without microlines. But all these are scarcely important differences and so we consider probably both conspecific. We have the same doubt as in the preceding species about how a non-planktotrophic species may be present in such widely separated places, but we consider the same explanation for this presence.



Figures 26-30. Opercula. 26, 27: *S. africana*; 28: *S.* cf. *puncticulata*; 29, 30: S. *yragoae* spec. nov. Figures 31, 32: Radulae: 31: *S.* cf. *puncticulata*; 32: S. *yragoae* spec. nov. Figure 33. Animal drawing of *S.* cf. *puncticulata*.

Figuras 26-30. Opérculos. 26, 27: S. africana*; 28:* S. *cf.* puncticulata*; 29, 30:* S. yragoae *spec. nov. Figuras 31, 32: Radulas: 31:* S. *cf.* puncticulata*; 32:* S. yragoae *spec. nov. Figura 33. Dibujo del animal de* S. *cf.* puncticulata.

CONCLUSIONS

In Dakar, there are several species of *Schwartziella*. In the present work, five are described. This is not a final number of the Dakar species, because some shells collected in small quantity and not mentioned in the present work could be different.

The species studied in Dakar are difficult to separate on the basis of additional characters like protoconch or microsculpture, because they are very similar to each other. Only the shell characters are constantly different (general shape, profile, higth/width ratio, features of the axial ribs).

The presence and abundance of the species studied was very variable in sediments from different localities in Dakar. Probably, this means that each species has its own particular habitat, and the abundance of the shells of each species in sediments varies according to the presence of this habitat in each area.

The different species have some degree of sympatry in each locality, as it is evident by sampling in several localities; the differences of the characters between these species are constant without intergrades.

ACKNOWLEDGMENTS

The authors thank Jacques Pelorce, Le Grau du Roi, France, for his collecting in Dakar where important information was recorded and also for the sediments and for the material sent for the present study. To Jesús Méndez of the Centro de Apoyo Científico y Tecnológico a la Investigacion (CACTI) of the University of Vigo for the SEM photographs. To the MNHN for the loan of the type material.

BIBLIOGRAPHY

DAUTZENBERG, P., 1912. Mission Gruvel sur la côte occidentale d'Afrique (1909-1910): Mollusques marins. *Annales de l'Institut Océanographique*, 5 (3): 1-111, pls. 52-54.

GOFAS, S., 1999. The West African Rissoidae (Gastropoda: Rissooidea) and their similarities to some European species. *The Nautilus*, 113 (3): 78-101.

ROLÁN, E. AND LUQUE, A. A., 2000. The subfamily Rissoininae (Mollusca: Gastropoda: Rissoidae) in the Cape Verde Archipelago (West Africa). *Iberus*, 18 (1): 21-94.

TALAVERA, F. G., 1979. Moluscos de sedimentos de la plataforma continental de Mauritania. *Boletín del Instituto Español de Oceanografía*, 192: 3-18.

© Sociedad Española de Malacología —————— *Iberus*, 21 (2): 133-139, 2003

Aspectos bioecológicos de *Gemma gemma* (Totten, 1894) (Pelecypoda: Veneridae) en la laguna de Chacopata, Venezuela

Biological aspects of *Gemma gemma* (Totten, 1894) (Pelecypoda: Veneridae) on Chacopata lagoon, Venezuela

Ildefonso LIÑERO ARANA* y Marelis MATA

Recibido el 9-IX-2002. Aceptado el 6-VII-2003

RESUMEN

Gemma gemma (Totten, 1894) es un pelecípodo endofaunal ovovivíparo, generalmente no mayor de 5 mm de longitud, y la especie más abundante en la laguna de Chacopata, situada en la costa nororiental de Venezuela (10° 39′ 00″ - 10° 41′ 00″ N y 63° 47′ 30″ - 60° 49′ 50″ O). En esta laguna, se tomaron mensualmente 9 réplicas de sedimento durante 12 meses, a partir de noviembre de 1995. La densidad mensual promedio fue de 2176 ± 4032,36 ind.m^{-2}, siendo enero, febrero y noviembre los meses que presentaron los valores más elevados (12039, 8658 y 3919 ind.m^{-2}, respectivamente). Los especímenes colectados presentaron tallas comprendidas entre 0,450 y 4,250 mm. El periodo de liberación de los embriones ocurre desde septiembre hasta marzo, observándose dos periodos de reclutamiento uno en noviembre 95 - enero 96 y otro de febrero a abril 96. A diferencia de lo que ocurre en latitudes altas de la costa de Estados Unidos, las mayores densidades se presentan durante los meses de menor temperatura, posiblemente debido al efecto estresante de este factor durante los meses más cálidos.

ABSTRACT

Gemma gemma (Totten, 1894) is an endofaunal ovoviviparous and dioecious pelecypod, generally not greater than 5 mm of length, and the species most abundant in the lagoon of Chacopata, located in the Northeast coast of Venezuela (10° 39′ 00″ - 10° 41′ 00″ N and 63° 47′ 30″ - 60° 49′ 50″ W). In this lagoon, 9 monthly sediment replicates were taken during 12 months, from November 1995. The monthly density average was of 2176 ± 4032,36 ind.m^{-2}, being January, February and November the months with the topmost values (12039, 8658 and 3919 ind.m^{-2}, respectively). The lengths of the collected specimens range between 0,450 and 4,250 mm. Brood release period takes place from September to March, being observed two recruitment periods, one from November 95 to January 96 and other from February 96 to April 96. Against what it occurs in high latitudes of the United States coast, the greater densities were observed during the months of smaller temperature, possibly due to the stress of this factor during the warmest months.

PALABRAS CLAVE: *Gemma gemma*, pelecípodo, macrofauna, laguna
KEY WORDS: *Gemma gemma*, pelecypod, macrofauna, lagoon.

* Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná, Venezuela. e-mail: ilinero@cantv.net

INTRODUCCIÓN

Gemma gemma (Totten, 1894) es un pelecípodo endofaunal ovovivíparo, de dimensiones reducidas, generalmente no mayor de 5 mm de longitud, que habita en fondos poco profundos desde Nueva Escocia hasta Florida, Texas y Las Bahamas, y ha sido introducida en las Antillas por aves limícolas migratorias (ABBOTT, 1974). Este bivalvo es la especie más abundante en la Laguna de Chacopata, sus poblaciones se distribuyen en parches y puede alcanzar densidades de hasta más de 86000 ind.m^{-2} en algunas zonas, constituyendo una fracción importante de la dieta de aves limícolas migratorias y residentes (LIÑERO, 1994). Debido a la importancia numérica y ecológica de esta especie en la laguna, se consideró de interés realizar un estudio sobre diversos aspectos de su bioecología.

MATERIAL Y MÉTODOS

La Laguna de Chacopata está situada en la costa nororiental de Venezuela, aproximadamente entre 10° 39´ 00˝ y 10° 41′ 00˝ N y 63° 47′ 30˝ y 60° 49′ 50˝ O, es un cuerpo de agua de aproximadamente 4 km de longitud máxima en sentido NE-SO, y de 2 km de anchura máxima. No posee aportes de agua dulce, excepto los provenientes de las escorrentías durante la época de lluvias. Presenta una angosta comunicación (aproximadamente 20 m de anchura) con el Mar Caribe. Las orillas están bordeadas de manglares, excepto en la costa sur, donde son escasos y poco desarrollados. La profundidad media es de unos 50-60 cm, presentando las mayores profundidades en las cercanías de la bocana (3-4 m). En la zona surcentral de la laguna se establecieron 4 estaciones equidistantes 50 m a lo largo de un transecto lineal, con una profundidad comprendida entre 40 y 60 cm. Con frecuencia mensual, durante 12 meses, a partir de noviembre de 1995, se tomaron 9 réplicas de sedimento con nucleadores de PVC de 5 cm de diámetro y 15 cm de longitud. En cada muestreo se tomaron registros de la temperatura y muestras adicionales de sedimento para su análisis granulométrico y de contenido de materia orgánica.

El análisis granulométrico se realizó por tamizado y el contenido de materia orgánica se estimó por la pérdida de peso de la muestra seca (100 °C, 24 h), después de combustión a 500 °C durante 24 h (LÓPEZ-JAMAR, 1981).

Las muestras de sedimento fueron lavadas a través de una serie de tamices, siendo el último de 250 µm de apertura de malla. Los especímenes retenidos fueron fijados en formalina al 8% en agua de mar. A cada ejemplar se le determinó la longitud antero-posterior y dorso-ventral y el número y tamaño de los huevos en las hembras ovadas.

Se realizó análisis de varianza y prueba a posteriori SNK (SOKAL Y ROHLF, 1980), para determinar el efecto de los meses y de las estaciones sobre los parámetros biológicos. Cuando los datos no cumplían los supuestos del ANOVA, se aplicó la prueba no paramétrica de Kruskal-Wallis, seguida de la prueba a posteriori correspondiente. Las relaciones entre las longitudes antero-posterior y la dorso-ventral, así como entre el número de huevos y la talla de los ejemplares se analizaron a través de análisis de regresión.

RESULTADOS

La temperatura del agua en el fondo estuvo comprendida entre 26 °C (enero y abril) y 30 °C (agosto), con un promedio de 27,8 °C. Los sedimentos de las estaciones mostraron un predominio de la fracción arena, predominando las arenas fina y media; mientras que la fracción fina, correspondiente a limo-arcilla, mostró porcentajes comprendidos entre 7 y 14%. Las partículas más gruesas, guija y gránulo, son casi en su totalidad de origen biogénico, principalmente restos de exoesqueletos de gasterópodos y de bivalvos, y muy particularmente de *G. gemma*. El contenido de materia orgánica de los sedimentos

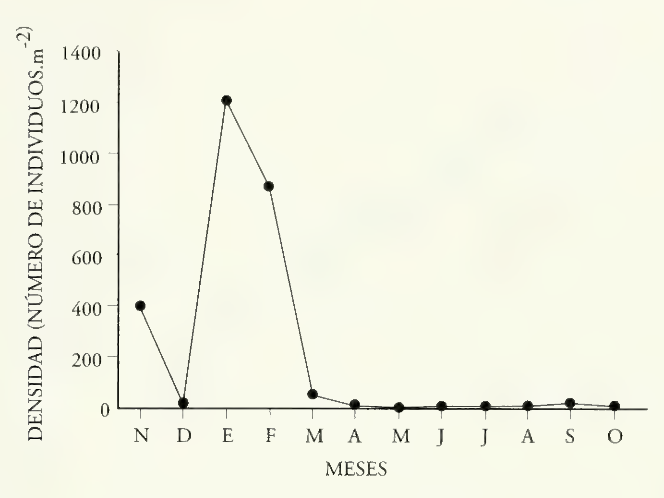


Figura 1. Evolución mensual de la densidad de *Gemma gemma*.
Figure 1. Monthly evolution of Gemma gemma *density.*

de las estaciones mostró valores entre 6,16 y 12,98%

La densidad mensual promedio fue de 2176 ± 4032,36 ind.m^{-2}, siendo enero, febrero y noviembre los meses que presentaron los valores más elevados (12039, 8658 y 3919 ind.m^{-2}, respectivamente); en los demás meses la densidad estuvo comprendida entre 28 (mayo) y 538 en marzo (Fig. 1). La densidad mensual promedio por estación estuvo comprendida entre 1382 ind.m^{-2} (estación 2) y 2862 ind.m^{-2} en la estación 1 ($\bar{x}$= 2176 ± 628,89). No se encontraron diferencias significativas de la densidad entre las estaciones de muestreo, pero sí entre los meses ($p < 0,005$).

Los especímenes colectados presentaron tallas comprendidas entre 0,450 y 4,250 mm. Una fracción importante de la población (63%) mostró talla promedio de 2,305 ± 0,688 mm. No se pudo realizar un análisis de la distribución mensual de tallas debido a que los valores de densidad variaron significativamente entre meses, por lo que se estudió la distribución trimestral de frecuencias de tallas en los dos primeros trimestres de estudio, debido a que en los otros dos el número de especímenes colectados fue bajo. De acuerdo a este análisis (Fig. 2) en los dos periodos (noviembre 95 - enero 96 y febrero – abril 96) se aprecian dos modas, aunque menos marcadas en el segundo trimestre, lo que evidencia la existencia de dos periodos de reclutamiento. En el tercer y cuarto trimestre no se colectaron individuos con talla inferior a 1,2 mm, lo que aunado al escaso número de individuos, indica ausencia de reclutamiento.

La correlación entre la longitud antero-posterior (LAP) y la dorsoventral (LDV) fue altamente significativa ($r = 0,975$, $p < 0,001$) (Fig. 3). La ecuación predictiva que representa la relación entre estas dos variables fue LDV = 0,04 + 1,10LAP.

La correlación entre la longitud antero-posterior de las hembras ovadas (x) y el número de huevos por hembra (y) fue significativa ($r = 0,52$, $p < 0,01$), y la ecuación obtenida fue $y = -12,88 + 9,62x$ (Fig. 4).

Se diferenciaron tres etapas de desarrollo de los huevos, la etapa I corresponde a huevos esféricos, de color blanco, con un diámetro entre 99 y 184 µm ($\bar{x}$= 131,16 µm); la etapa II incluye huevos ovalados de aspecto cristalino y diámetro entre 201 y 279 µm ($\bar{x}$= 275,87µm), y la etapa III corresponde a embriones con características similares a las del adulto y diámetro entre 309 y 500 µm ($\bar{x}$= 365,84 µm).

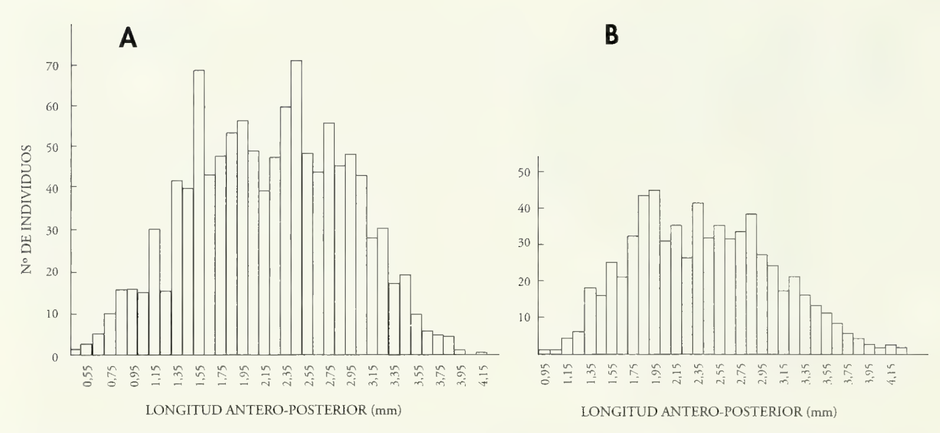


Figura 2. Distribución de frecuencias de tallas de *Gemma gemma*. A: periodo noviembre 95 – enero 96; B: periodo febrero 96 – abril 96.
Figure 2. Distribution of sizes frequencies of Gemma gemma. *A: period November 95 – January 96; B: period February 96 – April 96.*

DISCUSIÓN

La densidad de *G. gemma* en la laguna de Chacopata es baja en comparación con valores reportados para otras latitudes (entre 2 y 4.10^{6}), según THOMPSON (1982). Esta baja densidad puede ser debida a varias causas, unas relacionadas con aspectos bióticos y otras con aspectos físico-químicos. Entre las primeras se pueden citar principalmente el efecto de la depredación; a este respecto, SANDERS, GOUDSMIT, MILLS Y HAMPSON (1962) y GREEN Y HOBSON (1970), señalan, en Barnstable Harbor, la depredación de *G. gemma* por los crustáceos *Crangon septumspinosus* y *Limulus polyphemus*, respectivamente. Excluyendo las aves limícolas, debido a la profundidad de las estaciones, en la laguna existen potenciales depredadores de *G. gemma*, entre ellos varias especies de peces bentófagos, poliquetos y crustáceos, como *Farfantepenaeus* spp., *Callinectes* spp. y *Pagurus* spp. (LIÑERO, 1994).

Por otro lado, la temperatura es uno de los factores abióticos que puede influir en las bajas densidades; esta presunción se basa en el hecho de que las mayores densidades se obtuvieron en los meses menos cálidos; GREEN Y HOBSON (1970), en experimentos controlados, señalan que la temperatura superior letal para el 50% de los individuos de *G. gemma* es 35 °C. Durante este estudio la temperatura máxima registrada fue de 30 °C en agosto, pero es necesario señalar que las mediciones de este parámetro fueron realizadas entre las 09:00 y las 10:00 h aproximadamente; y en horas próximas al mediodía, entre las 11:00 y 14:00 h, la temperatura del agua de la laguna es mayor, por efecto de la intensa insolación, baja profundidad y escaso movimiento del agua, en particular durante los meses más cálidos (mayo-septiembre).

En la laguna esta especie habita prácticamente en la superficie del sedimento, y las elevadas temperaturas podrían constituir el principal factor abiótico que limite la abundancia de esta especie, bien sea por alcanzar niveles letales o por producir un menor número de embriones, aun cuando GREEN Y HOBSON (1970) reportan que *G. gemma* puede eludir temperaturas extremas de la superficie del fondo, enterrándose al menos hasta 4 cm en el sedimento, estrategia que podría presentar también en la laguna.

En zonas someras estos organismos pueden ser arrastrados por las corrientes producidas durante los periodos de mayor intensidad del viento hasta fondos

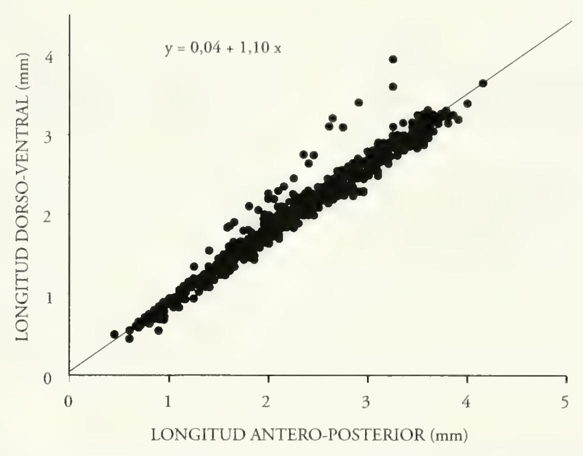


Figura 3. Regresión entre la longitud dorso-ventral y la longitud antero-posterior de *Gemma gemma*.
Figure 3. The regression of dorsal-ventral and the antero-posterior lengths on Gemma gemma.

donde la intensidad de la corriente sea menor (THOMPSON, 1982). En la laguna, como en el resto de la costa caribeña de Venezuela, la amplitud de las mareas es débil, de aproximadamente 30 cm, por lo que las corrientes en la laguna son debidas principalmente a la acción de los vientos alisios, que se presentan con mayor intensidad en la época de sequía (noviembre-abril). Esta característica, aunada a la distribución temporal de la temperatura, podría explicar la variación de las densidades en la población estudiada. Es probable que exista un transporte de individuos de zonas someras (< 30 cm) hacia fondos de mayor profundidad, donde la intensidad de la corriente se debilite por efecto de la profundidad. Esto ocurriría durante el periodo noviembre-abril, durante el cual individuos de poblaciones someras serían arrastrados hacia fondos más profundos. Durante los meses más cálidos, la intensidad del viento decrece notablemente, por lo que el transporte no se produciría o los organismos podrían migrar a más profundidad en el sedimento, según lo señalado por GREEN Y HOBSON (1970).

En la laguna existen dos especies de algas filamentosas (*Chaetomorpha* sp. y *Cladophora* sp.) que alcanzan gran desarrollo durante los meses más cálidos. Estas algas, adheridas precariamente principalmente a restos de conchas de gasterópodos y pelecípodos, durante los meses secos y de alta intensidad de los alisios, son desprendidas y arrastradas hasta los márgenes de la laguna, donde se acumulan y descomponen. En esas aglomeraciones de algas se han observado numerosos ejemplares de *G. gemma* entre los frondes filamentosos, lo cual puede ser atribuido a que individuos de este pelecípodo son arrastrados por las corrientes y retenidos por las algas, o que son removidos del fondo por las algas cuando éstas son desplazadas por las corrientes en zonas de poca profundidad y quedan atrapados en los numerosos y tupidos filamentos, o a la acción conjunta de ambas acciones.

La longitud del periodo de liberación de los embriones parece estar influenciada por la latitud y/o la temperatura (THOMPSON, 1982). Este autor compara características de la reproducción y el desarrollo de *G. gemma* en San Francisco Bay, California (37° 45´), con estudios realizados en Barnstable Harbor, Massachusetts (41° 42´) y en Union Beach, New Jersey (40° 27´). En San Francisco Bay, la duración del periodo de liberación de los embriones es de 7 meses, en Barnstable Harbor es de 3 meses, y en Union Beach de 5 meses. En la Laguna de Chacopata se colectaron hembras ovadas en los

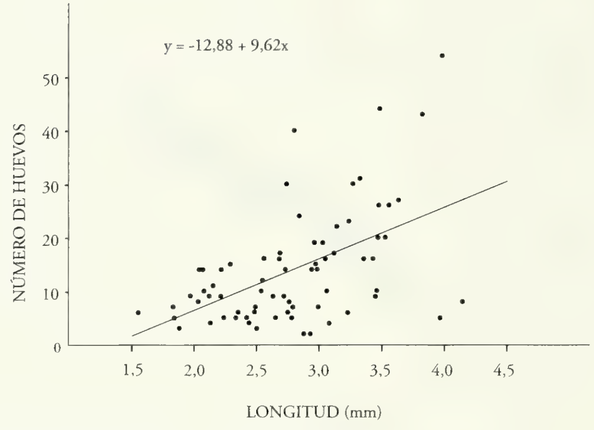


Figura 4. Regresión del número de huevos de *Gemma gemma* según la talla.
Figure 4. The regression of egg number on Gemma gemma *size.*

meses de enero a marzo y de septiembre a noviembre, lo que aunado a la distribución trimestral de tallas permite afirmar que el periodo de liberación de los embriones de *G. gemma* ocurre desde septiembre hasta marzo, comprendiendo los meses de menores temperaturas y, al igual que en San Francisco Bay, el periodo de liberación de los embriones comprende 7 meses.

En la Figura 4 se aprecia que en prácticamente todas las tallas se presentan hembras con un número de huevos relativamente bajo, inferior a 20, y que solamente el 7% de las hembras poseen más de 30 huevos, correspondiendo el máximo de 54 para una hembra de 3,99 mm. Estos resultados difieren notablemente de los obtenidos por GREEN Y HOBSON (1970), quienes en la figura 8 de su trabajo presentan al 64% de las hembras con más de 30 huevos, y dos de ellas con hasta 100 huevos. Al igual que en el trabajo de Green y Hobson, en este estudio la talla mínima de producción de embriones se encuentra cercana a los 1,7 mm. La diferencia en el número de huevos/hembra entre estos dos estudios puede ser debida a que los huevos de *G. gemma* en Massachussets sean de menor tamaño que los de la Laguna de Chacopata, tomando en consideración que el tamaño de los individuos en las dos poblaciones son similares; sin embargo, no se dispone de referencias sobre el tamaño de los huevos de este pelecípodo en otras latitudes que puedan confirmar esta hipótesis, aunque Sullivan (1948, citado por BRADLEY Y COOKE, 1959) menciona que cuando los huevos van a ser liberados miden 340 µm.

THOMPSON (1982) atribuye el mayor éxito de las poblaciones de *G. gemma* en San Francisco Bay con relación a poblaciones de latitudes mayores, al clima cálido de esa bahía, lo cual se traduce en periodos reproductivos de mayor duración y mayor número de reclutamientos, obteniendo las mayores densidades en julio y agosto, durante el periodo de máximo reclutamiento y las menores en los meses que preceden inmediatamente al reclutamiento. En la Laguna de Chacopata ocurre lo contrario, las menores densidades se producen en los meses más cálidos, por lo que podría deducirse que para esta especie su intervalo de temperatura óptima de reproducción y desarrollo se encuentra por debajo de 30 °C.

AGRADECIMIENTOS

Los autores desean expresar su agradecimiento a los revisores anónimos por las observaciones realizadas al manuscrito, las cuales permitieron mejorarlo notablemente.

BIBLIOGRAFÍA

Bradley, W. H. y Cooke, P., 1959. Living and ancient populations of the clam *Gemma gemma* in a Maine coast tidal flat. *Fishery Bulletin*, 58: 306-337.

Green, R. H. y Hobson, K. D., 1970. Spatial and temporal structure in a temperate intertidal community, with special emphasis on *Gemma gemma* (Pelecypoda: Mollusca). *Ecology*, 51 (6): 999-1011.

Liñero, I., 1994. *Variations spatio-temporelles de la structure des peuplements benthiques dans une lagune côtière tropicale.* Thèse Ph. D. Université du Québec à Rimouski, Canadá, 177 pp.

López-Jamar, E. 1981. Spatial Distribution of the Infaunal Benthic Communities of the Ría de Muros, North-West Spain. *Marine Biology*, 63: 29-37.

Sanders, H. L., Goudsmit, E. M., Mills, E. L. y Hampson, G. E., 1962. A study of the intertidal fauna of Barnstable Harbor, Massachusetts. *Limnology and Oceanography*, 7: 63-79.

Thompson, J. K., 1982. Population structure of *Gemma gemma* (Bivalvia: Veneridae) in South San Francisco Bay, with a comparison to some Northeastern United States estuarine populations. *Veliger*, 24 (3): 281-290.

Notas Breves

Nueva información sobre *Paladilhiopsis septentrionalis* (Mollusca, Prosobranchia)

New information on *Paladilhiopsis septentrionalis* (Mollusca, Prosobranchia)

Emilio ROLÁN* y Beatriz ARCONADA**

Recibido el 9-XII-2002 Aceptado el 10-VI-2003

INTRODUCCIÓN

ROLÁN Y RAMOS (1995) describen *Paladilhiopsis septentrionalis* en base a conchas recolectadas en las provincias de Santander, Vizcaya, Álava y Burgos; en ningún caso se encontraron ejemplares vivos o con restos de partes blandas debido a que, probablemente, se trataba de una especie estigobionte.

En recientes muestreos realizados por el primer autor en Asturias, se volvieron a encontrar conchas de esta especie en varias localidades, e incluso se consiguió la captura de un ejemplar vivo, por lo que se aporta nueva información sobre esta especie.

MATERIAL ESTUDIADO

Coordenadas UTM:

TP50: Trubia (Oviedo), en el camino de Trubia a Caces, que sale desde la estación del ferrocarril, antes de la fábrica del Nalón, y que va entre este río y la vía del tren, en un pequeño nacimiento en una pared, a 2,8 Kms de la estación de Trubia y a 1,7 Kms de la desviación a Pintoria: 1 ejemplar vivo, 18 conchas y 22 fragmentos.

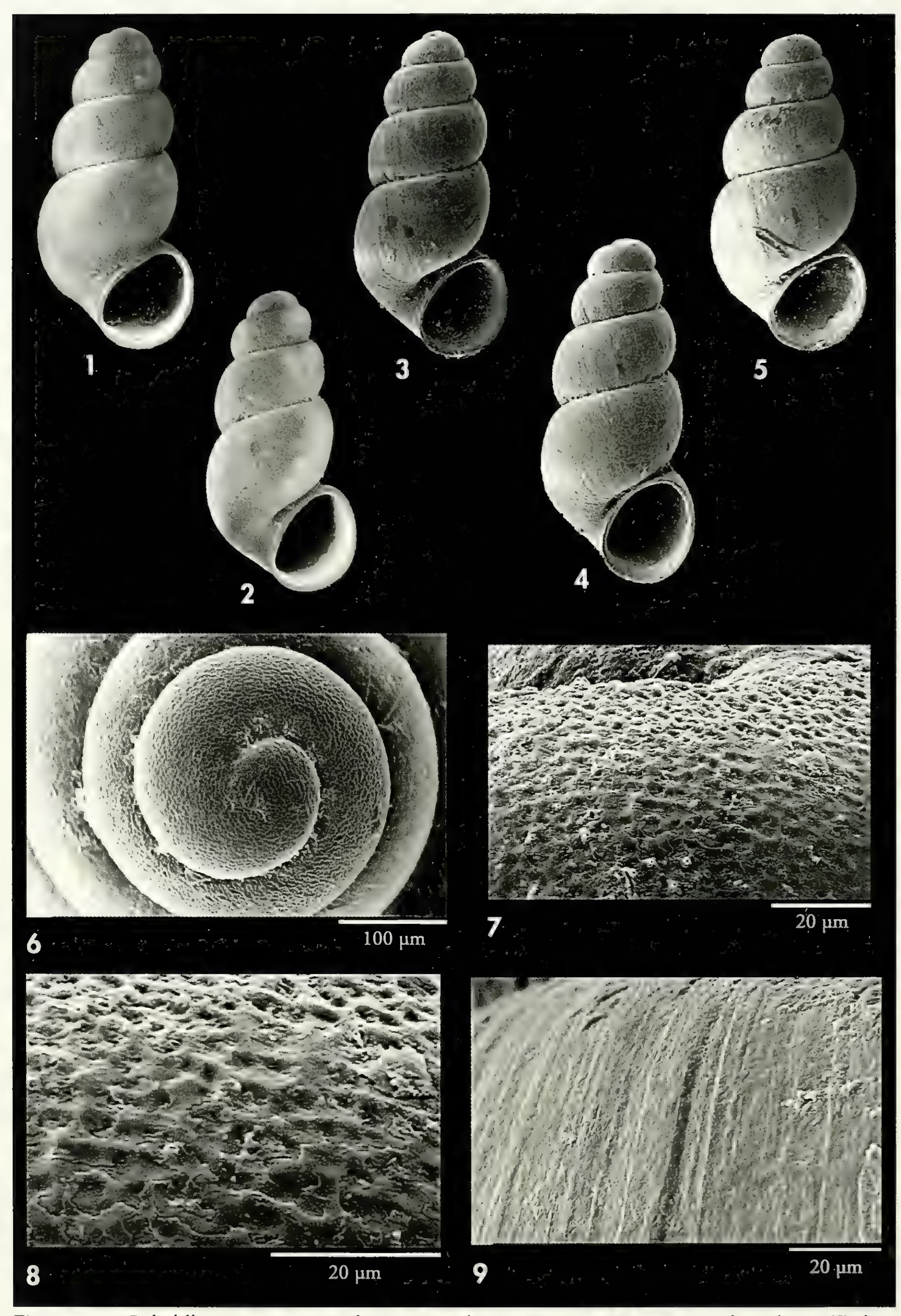
TP50: Carretera de Trubia a Proaza, en la desviación a Castañedo del Monte, a poco del comienzo de la misma, en un barranco al lado de una fuente, en sedimentos: 1 concha.

QJ30: Carretera de Grado a Tameza, en sedimentos de la fuente frente al río: 1 concha.

RESULTADOS

Descripción: Concha (Figs. 1-5): Ver ROLÁN Y RAMOS (1995). Las conchas estudiadas ahora en las nuevas estaciones tenían una apariencia muy similar a las presentadas en el trabajo de descripción, lo mismo que la protoconcha (Fig. 6) y su escultura (Figs. 7-8). En el único ejemplar vivo observado, la concha era transparente, al contrario de lo que ocurre en las conchas vacías, que se vuelven opacas y de color blanco. Las

* Investigador del Museo de Historia Natural, Campus Universitario Sur, 15782, Santiago de Compostela.
** Museo Nacional de Ciencias Naturales, J. Gutierrez Abascal, 2, 28006 Madrid.



Figuras 1-9. *Paladilhiopsis septentrionalis*. 1-5: conchas, entre 1,2 y 1,5 mm, recolectadas en Trubia, Asturias; 6: protoconcha; 7, 8: microescultura de la protoconcha; 9: microescultura de la teloconcha.
Figures 1-9. Paladilhiopsis septentrionalis. 1-5: shells, between 1.2 and 1.5 mm, collected in Trubia, Asturias; 6: protoconch; 7, 8: microsculpture of the protoconch; 9: microsculpture of the teleoconch.

dimensiones de las conchas del material estudiado estaban entre 1,2 y 1,5 mm.

Microescultura de la teloconcha (Fig. 9): Similar a la de la descripción original, aunque algo más atenuada.

Animal: Se pudo observar que era casi totalmente transparente, con un tono lechoso muy ligero. La rádula, de color blanco, podía verse perfectamente por transparencia. Los tentáculos finos y alargados. No se apreciaban ojos en la base de los mismos. Lamentablemente, el tubo se quedó casi sin líquido y el animal se secó bastante, con lo que no se pudieron observar detalles anatómicos en su disección. Sí se pudo apreciar que se trataba de una hembra. La gonada que se veía en el último tramo del cuerpo era de color naranja y con forma de saco. El ctenido aparecía poco desarrollado, con dos lamellas minúsculas.

CONCLUSIONES

El área de distribución de *P. septentrionalis*, aunque incluía varias provincias, era en realidad muy pequeña (ver ROLÁN Y RAMOS, 1995). Con la presente cita esta distribución se extiende notablemente hacia el oeste, hasta Asturias. Por otra parte, el hallazgo de un ejemplar vivo, muestra que aun siendo una especie estigobionte, su distancia a la superficie no es muy grande, y por ese motivo pueden aparecer ocasionalmente ejemplares vivos arrastrados por el agua.

AGRADECIMIENTOS

Los autores agradecen a Jesús Méndez, del CACTI, Universidad de Vigo, las fotografías realizadas el MEB.

BIBLIOGRAFÍA

ROLÁN, E. Y RAMOS, M. A. 1995. Una nueva especie de Hydrobiidae (Mollusca, Prosobranchia) del norte de la Península Ibérica. *Iberus*, 13 (2): 119-127.

ERRATUM

In the article

FRANCK BOYER, 2003. The Cystiscidae (Caenogastropoda) from upper reef formations of New Caledonia". Iberus, 21 (1): 241-272.

a wrong numbering was introduced within the second plate of figures. The numbering attached to the pictures must be changed as following:

nº 20 becomes nº 18
nº 18 becomes nº 19
nº 21 becomes nº 20
nº 19 becomes nº 21

The numbering used in the text and in the captions are right.

NORMAS DE PUBLICACIÓN

• La revista *Iberus* publica artículos de fondo, notas y monografías que versen sobre cualquiera de los aspectos relacionados con la Malacología. Se entiende por artículo un trabajo de investigación de más de 5 páginas de texto, mecanografiadas, incluidas láminas, gráficos y tablas. Las notas son trabajos de menor extensión. Las monografías son trabajos sobre un tema único, de extensión superior a las 50 páginas de la revista y que serán publicadas como un suplemento de *Iberus*. Los autores interesados en publicar monografías deberán ponerse previamente en contacto con el Editor de Publicaciones. Se entiende que el contenido de los manuscritos no ha sido publicado, ni se publicará en otra parte ni en su totalidad ni resumido.

• Los manuscritos, así como toda la correspondencia relacionada con los mismos, deberán ser remitidos a: D. Gonzalo Rodríguez Casero, Editor de Publicaciones, Apartado 156, 33600 Mieres, Asturias, España.

• El texto del trabajo podrá estar redactado en cualquier lengua culta moderna.

• En los trabajos que superen las 20 páginas, cada página de exceso será abonada por el(los) autor(es) a precio de coste.

• Los artículos, notas y monografías deberán presentarse mecanografiados sobre DIN A-4, por una sola cara a doble espacio (incluyendo referencias, pies de figura y tablas), con al menos 3 centímetros de margen por cada lado. Los trabajos se entregarán por triplicado (original y dos copias). En caso de autoría compartida, uno de los autores deberá hacerse responsable de toda la correspondencia.

• Junto con el trabajo debe incluirse una lista de al menos 4 posibles revisores del mismo, sin perjuicio de los que el propio Editor considere oportunos.

• Los manuscritos se presentarán de acuerdo al siguiente esquema:

Primera página. Deberá incluir un título conciso, pero sugerente del contenido del trabajo, así como una traducción al inglés del mismo (si el artículo no está escrito en inglés). Cuando sea preciso, deberá incluir referencia a familia o táxones superiores. A continuación figurarán, por este orden, el nombre y apellidos completos del autor o autores, las direcciones completas de los mismos, y un resumen del trabajo y su traducción al inglés. Dicho resumen deberá sintetizar, en conjunción con el título, tanto los resultados como las conclusiones del artículo; se sugiere una extensión de 100 a 200 palabras. El resumen deberá estar seguido de una lista de palabras clave, también con su versión inglesa para su inclusión en los bancos de datos internacionales.

Páginas siguientes. Incluirán el resto del artículo, que debe dividirse en secciones precedidas por breves encabezamientos. Siempre que sea posible, se recomienda seguir el siguiente esquema: Introducción, Material y métodos, Resultados, Discusión, Conclusiones, Agradecimientos y Bibliografía. Si se emplean abreviaturas no habituales en el texto, deberán indicarse tras el apartado de Material y Métodos.

• Las notas breves deberán presentarse de la misma forma, pero sin resumen.

• Deberán evitarse notas a pie de página y referencias cruzadas. Deberán respetarse estrictamente los Códigos Internacionales de Nomenclatura Zoológica y Botánica (últimas ediciones). Cuando un táxon aparezca por primera vez deberá citarse su autor y fecha de su descripción. En el caso de artículos sistemáticos, cuando se den las sinonimias de los táxones, éstas deberán citarse COMPLETAS, incluyendo en forma abreviada la publicación donde fueron descritas, y la localidad tipo si es conocida entre corchetes, según el siguiente esquema (préstese especial cuidado a la puntuación):

***Dendrodoris limbata* (Cuvier, 1804)**
Sinonimias
Doris limbata Cuvier, 1804, *Ann. Mus. H. N. Paris*, 4 (24): 468-469 [Localidad tipo: Marsella].
Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop. Car.*, 10: 275.

Dichas referencias no deberán incluirse en la lista de Bibliografía si es la única vez que se nombran en el texto.
Si se incluyen una lista completa de referencias de un taxon inmediatamente tras éste, deberá seguirse el mismo esquema (sin incluir en Bibliografía las referencias que no se mencionen en otro lugar del texto).

• Sólo los nombres en latín y los de táxones genéricos y específicos deberán llevar subrayado sencillo o preferentemente ir en cursiva. En ningún caso deberá escribirse una palabra totalmente en letras mayúsculas, ni siquiera el Título. Las unidades a utilizar deberán pertenecer al Sistema Métrico Decimal, junto con sus correctas abreviaturas. En artículos escritos en castellano, en los números decimales sepárese la parte entera de la decimal por una coma inferior (,), NUNCA por un punto (.) o coma superior (').

• Las referencias bibliográficas irán en el texto con minúsculas o versalitas: Fretter y Graham (1962) o FRETTER Y GRAHAM (1962). Si son más de dos autores se deberán citar todos la primera vez que aparecen en el texto [Smith, Jones y Brown (1970)] empleándose *et al.* las siguientes veces [Smith *et al.* (1970)]. Si un autor ha publicado más de un trabajo en un año se citarán con letras: (Davis, 1989a; Davis, 1989b). No deberá emplearse *op. cit.* La lista de referencias deberá incluir todas las citas del texto y sólo éstas, ordenadas alfabéticamente. Se citarán los nombres de todos los autores de cada referencia, sea cual sea su número. Los nombres de los autores deberán escribirse, en letras minús-

culas o VERSALITAS. No deberán incluirse referencias a autores cuando éstos aparezcan en el texto exclusivamente como autoridades de un taxon. Los nombres de las publicaciones periódicas deberán aparecer COMPLETOS, no abreviados. Cuando se citen libros, dése el título, editor, lugar de publicación, nº de edición si no es la primera y número total de páginas. Deberán evitarse referencias a Tesis Doctorales u otros documentos inéditos de difícil consulta. Síganse los siguientes ejemplos (préstese atención a la puntuación):

Fretter, V. y Graham, A., 1962. *British Prosobranch Molluscs.* Ray Society, London, 765 pp.

Ponder, W. F., 1988. The Truncatelloidean (= Rissoacean) radiation - a preliminary phylogeny. En Ponder, W. F. (Ed.): Prosobranch Phylogeny, *Malacological Review*, suppl. 4: 129-166.

Ros, J., 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoolgica*, 3 (5): 21-51.

• Las gráficas e ilustraciones deberán ser originales y presentarse sobre papel vegetal o similar, con tinta china negra y ajustadas al formato de caja de la revista o proporcional a éste. Este formato es de 57 mm (una columna) o 121 mm (dos) de anchura y hasta 196 mm de altura, si bien se recomienda utilizar el formato a dos columnas. En caso de preparar figuras para que ocupen el total de una página, se ruega ajustar su tamaño para que puedan caber los pies de figura bajo ella. Si han de incluirse gráficas de ordenador, deberán imprimirse con impresora láser sobre papel de buena calidad. Las fotografías, bien contrastadas y sin retocar, deberán ajustarse siempre a los tamaños mencionados. Al componer fotografías sobre una hoja, procúrese que los espacios entre ellas sean regulares y que estén debidamente alineadas. Téngase en cuenta que incluir fotografías de distinto contraste en una misma página conlleva una pobre reproducción final. Las escalas de dibujos y fotografías deberán ser gráficas, y las unidades que se utilicen del sistema métrico decimal. Considérese la reducción que será necesaria a la hora de decidir el tamaño de las escalas o letras en las figuras, que no deberán bajar de los 2 mm. En figuras compuestas, cada parte deberá etiquetarse con letras mayúsculas, el resto de las letras deberán ser minúsculas. No deberán hacerse referencias a los aumentos de una determinada ilustración, ya que éstos cambian con la reducción, por lo que debe emplearse una escala gráfica. En su caso, se recomienda la utilización de mapas con proyección UTM. Cada figura, gráfica o ilustración deberá presentarse en hojas separadas y con numeración arábiga (1, 2, 3,...), sin separar "Figuras" y "Láminas". Los pies de figura, en una hoja aparte, deberán acompañarse de su traducción al inglés (o español si el inglés es la lengua del trabajo). Utilícese el esquema siguiente:

Figura 1. *Neodoris carvi.* A: animal desplazándose; B: detalle de un rinóforo; C: branquia.

Las abreviaturas empleadas en las ilustraciones deberán incluirse en la hoja de pies de figura.

Los autores interesados en incluir láminas en color deberán abonarlas a precio de coste (30.000 ptas por página). Por lo demás, deberán ajustarse a los mismos requisitos que los indicados para las figuras.

Si se pretende enviar gráficas o ilustraciones en formato digital es IMPRESCINDIBLE contactar previamente con el Editor

• Las Tablas se presentarán en hojas separadas, siempre con numeración romana (I, II, III,...). Las leyendas se incluirán en una hoja aparte acompañándose de una traducción al inglés. Deberán evitarse las tablas particularmente complejas. Se recomienda reducir el número y extensión de ilustraciones, láminas o tablas al mínimo necesario.

• Los artículos que no se ajusten a las normas de publicación serán devueltos al autor con las indicaciones de los cambios necesarios.

• El Comité Editorial comunicará al autor responsable del trabajo la fecha de recepción del trabajo y la fecha de envío a revisión. Cada original recibido será sometido a revisión por al menos dos investigadores. El Comité Editorial, a la vista de los informes de los revisores decidirá sobre la aceptación o no de cada manuscrito. El autor recibirá en cada caso copia de los comentarios de los revisores sobre su artículo. En caso de aceptación, el mismo Comité Editorial, si lo considera conveniente, podrá solicitar a los autores otras modificaciones que considere oportunas. Si el trabajo es aceptado, el autor deberá enviar una copia impresa del mismo corregida, acompañada por una versión en disco flexible (diskette), utilizando procesadores de texto en sus versiones de DOS o Macintosh. La fecha de aceptación figurará en el artículo publicado.

• Las pruebas de imprenta serán enviadas al autor responsable, EXCLUSIVAMENTE para la corrección de erratas, y deberán ser devueltas en un plazo máximo de 15 días. Se recomienda prestar especial atención en la corrección de las pruebas.

• De cada trabajo se entregarán gratuitamente 50 separatas. Aquellos autores que deseen un número mayor, deberán hacerlo constar al devolver las pruebas de imprenta, y NUNCA POSTERIORMENTE. El coste de las separatas adicionales será cargado al autor.

INSTRUCTIONS TO AUTHORS

• *Iberus* publishes research papers, notes and monographs devoted to the various aspects of Malacology. Papers are manuscripts of more than 5 typed pages, including figures and tables. Notes are shorter papers. Monographs should exceed 50 pages of the final periodical, and will be published as Supplements. Authors wishing to publish monographs should contact the Editor. Manuscripts are considered on the understanding that their contents have not appeared or will not appeared, elsewhere in substantially the same or any abbreviated form.

• Manuscripts and correspondence regarding editorial matters must be sent to: D. Gonzalo Rodríguez Casero, Editor de Publicaciones, Apartado 156, 33600 Mieres, Asturias, Spain.

• Manuscripts may be written in any modern language.

• When a paper exceeds 20 pages, extra pages will be charged to the author(s) at full cost.

• Manuscripts must be typed double spaced (including the references, figure captions and tables) on one side on A-4 (297x210 mm) with margins of at least 3 cm. An original and two copies must be submitted. When a paper has joint authorship, one author must accept responsability for all correspondence.

• The authors must include a list of at least 4 possible referees; the Editor can choose any others if appropriate.

• Papers should conform the following layout:

First page. This must include a concise but informative title, with mention of family of higher taxon when appropriatte, and its Spanish translation. It will be followed by all authors' names and surnames, their full adress(es), an abstract (and its Spanish translation) not exceeding 200 words which summarizes not only contents but results and conclusions, and a list of Key Words (and their Spanish translation) under which the article should be indexed.

Following pages. These should content the rest of the paper, divided into sections under short headings. Whenever possible the text should be arranged as follows: Introduction, Material and methods, Results, Discussion, Conclusions, Acknowledgements and References. Unusual abbreviations used in the text must be grouped in one alphabetic sequence after the Material and methods section.

• Notes should follow the same layout, without the abstract.

• Footnotes and cross-references must be avoided. The International Codes of Zoological and Botanical Nomenclature must be strictly followed. The first mention in the text of any taxon must be followed by its authority including the year. In systematic papers, when synonyms of a taxon are given, they must be cited IN FULL, including the periodical, in an abbreviate form, where they were described, and the type localities in square brackets when known. Follow this example (please note the punctuation):

Dendrodoris limbata **(Cuvier, 1804)**
Synonyms
Doris limbata Cuvier, 1804, *Ann. Mus. H. N. Paris*, 4 (24): 468-469 [Type locality: Marseille].
Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop. Car.*, 10: 275.

These references must not be included in the Bibliography list, except if referred to elsewhere in the text. If a full list of references of the taxon is to be given immediately below it, the same layout should be followed (also excluding those nowhere else cited from the Bibliography list).

Only Latin words and names of genera and species should be underlined once or be given in *italics*. No word must be written in UPPER CASE LETTERS. SI units are to be used, together with their appropriate symbols. In Spanish manuscripts, decimal numbers must be separated with a comma (,), NEVER with a point (.) or upper comma (').

• References in the text should be written in small letters or SMALL CAPITALS: Fretter and Graham (1962) or FRETTER AND GRAHAM (1962). The first mention in the text of a paper with more than two authors must include all of them [Smith, Jones & Brown (1970)], thereafter use *et al.* [Smith *et al.* (1970)]. If an author has published more than one paper per year, refer to them with letters: (Davis, 1989a; Davis, 1989b). Avoid *op. cit.*

The references in the reference list should be in alphabetical order and include all the publications cited in the text but only these. ALL the authors of a paper must be included. These should be written in small letters or SMALL CAPITALS. The references need not be cited when the author and date are given only as authority for a taxonomic name. Titles of periodicals must be given IN FULL, not abbreviated. For books, give the title, name of publisher, place of publication, indication of edition if not the first and total number of pages. Keep references to doctoral theses or any other unpublished documents to an absolute minimum. See the following examples (please note the punctuation):

Fretter, V. and Graham, A., 1962. *British Prosobranch Molluscs*. Ray Society, London, 765 pp.
Ponder, W. F., 1988. The Truncatelloidean (= Rissoacean) radiation - a preliminary phylogeny. In Ponder, W. F. (Ed.): Prosobranch Phylogeny, *Malacological Review*, suppl. 4: 129-166.
Ros, J., 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

• Figures must be original, in Indian ink on draughtsman's tracing paper. Keep in mind page format and column size when designing figures. These should be one column (57 mm) or two columns (121 mm) wide and up 196 mm high, or be proportional to these sizes. Two columns format is recomended. It is desirable to print figures with their legend below, so authors are asked to take this into account when preparing full page figures. If computer generated graphics are to be included, they must be printed on high quality white paper with a laser printer. Photographs must be of good contrast, and should be submitted in the final size. When mounting photographs in a block, ensure spacers are of uniform width. Remember that grouping photographs of varied contrast results in poor reproduction. Take account of necessary reduction in lettering drawings; final lettering must be at least 2 mm high. In composite drawings, each figure should be given a capital letter; additional lettering should be in lower-case letters. A scale line is recomended to indicate size, magnification ratio must be avoided as it may be changed during printing. UTM maps are to be used if necessary. Figures must be submitted on separate sheets, and numbered with consecutive Arabic numbers (1, 2, 3,...), without separating 'Plates' and 'Figures'. Legends for Figures must be typed in numerical order on a separate sheet, and an Spanish translation must be included. Follow this example (please note the punctuation):

Figure 1. *Neodoris carvi*. A: animal crawling; B: rinophore; C: gills.

If abbreviations are to be used in illustrations, group them alphabetically after the Legends for Figures section.

Authors wishing to publish illustrations in colour will be charged with additional costs (30,000 ptas, 180 euros per page). They should be submitted in the same way that black and white prints.

If the authors want to send Figures in digital format, CONTACT the Editor first.

• Tables must be numbered with Roman numbers (I, II, III,...) and each typed on a separate sheet. Headings should be typed on a separate sheet, together with their English translation. Complex tables should be avoided. As a general rule, keep the number and extension of illustrations and tables as reduced as possible.

• Manuscripts that do not conform to these instructions will be returned for correction before reviewing.

• Authors submitting manuscripts will receive an acknowledgement of receipt, including receipt date, and the date the manuscript was sent for reviewing. Each manuscript will be critically evaluated by at least two referees. Based of these evaluations, the Editorial Board will decide on acceptance or rejection. Anyway, authors will receive a copy of the referees' comments. If a manuscript is accepted, the Editorial Board may indicate additional changes if desirable. Acceptable manuscripts will be returned to the author for consideration of comments and criticism; a finalized manuscript must then be returned to the Editor, together with a floppy disk containing the article written with a DOS or Macintosh word processor. Dates of reception and acceptance of the manuscript will appear in all published articles.

• Proofs will be sent to the author for correcting errors. At this stage no stylistic changes will be accepted. Pay special attention to references and their dates in the text and the Bibliography section, and also to numbers of Figures and Tables appearing in the text.

• Fifty reprints per article will be supplied free of charge. Additional reprints must be ordered when the page proofs are returned, and will be charged at cost. NO LATER orders will be accepted.

La Sociedad Española de Malacología

Junta Directiva desde el 14 de noviembre de 2000

La *Sociedad Española de Malacología* se fundó el 21 de agosto de 1980. La sociedad se registró como una asociación sin ánimo de lucro en Madrid (Registro Nº 4053) con unos estatutos que fueron aprobados el 12 de diciembre de 1980. Esta sociedad se constituye con el fin de fomentar y difundir los estudios malacológicos mediante reuniones y publicaciones. A esta sociedad puede pertenecer cualquier persona o institución interesada en el estudio de los moluscos.

Sede social: Museo Nacional de Ciencias Naturales, c/ José Gutierrez Abascal 2, 28006 Madrid, España.

Cuotas para 2003:

Socio numerario	(en España):	33,06 euros
	(en Europa)	36,06 euros
	(fuera de Europa):	42,07 euros
Socio estudiante	(en España):	18,03 euros
	(en el extranjero):	24,04 euros
Socio Familiar:	(sin recepcion de revista)	3 euros
Socio Protector:	(mínimo)	42,07 euros
Socio Corporativo	(en Europa):	42,07 euros
	(fuera de Europa):	48,08 euros

Inscripción: 6,01 euros, además de la cuota correspondiente.

A los socios residentes en España se les aconseja domiciliar su cuota. Todos los abonos deberán enviarse al Tesorero (dirección reseñada anteriormente) el 1 de enero de cada año. Los abonos se harán sin recargos para la sociedad y en favor de la *Sociedad Española de Malacología* y no de ninguna persona de la junta directiva. Aquellos socios que no abonen su cuota anual dejarán de recibir las publicaciones de la Sociedad. Los bonos de inscripción se enviarán junto con el abono de una cuota anual al Tesorero.

Members living in foreing countries can deduce 6 euros if paid before 15 April.

Cada socio tiene derecho a recibir anualmente los números de *Iberus, Reseñas Malacológicas* y *Noticiarios* que se publiquen.

Índice

Iberus 21 (2) 2003

ISSN 0212-3010